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ABSTRACT

The Atlantic barrier system is used as a focal point in this manual of field exercises. A collection of activities and posed questions provide students with opportunities to develop skills basic to the development of sound field techniques. Investigations can be adapted and modified by teachers to specific subject areas and developmental needs. Each exercise is formatted with an introductory statement, materials list, and procedural directives. Student activities include: (1) beach geomorphology; (2) tidal cycles; (3) littoral observations; (4) longshore currents; (5) sediments; (6) beach profiling; (7) core sampling; and (8) plant communities. This guide also contains a variety of diagrams, illustrations, and reference tables. (ML)

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FIELD TECHNIQUES: ATLANTIC BARRIER SYSTEM

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1984 ANNUAL FIELD CONFERENCE

NATIONAL ASSOCIATION OF GEOLOGY TEACHERS, EASTERN SECTION

UNIVERSITY OF DELAWARE MARINE STATION - LEWES, DE

NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

EASTERN SECTION

ANNUAL FIELD CONFERENCE APRIL 26-29, 1984

FIELD TECHNIQUES:

ATLANTIC BARRIER SYSTEM

Field Guidebook

James V. O'Connor and Brian B. Tormey, eds.

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and
The Pennsylvania State University
Altoona Campus

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INTRODUCTION

We have prepared this field guide for multiple use. For students, we have written a collection of exercises and posed questions, that not only provide an introduction to the Atlantic barrier system, but also present an opportunity to develop skills basic to the development of sound field study technique across a spectrum of disciplines. For teachers, perhaps the guide may be best utilized as a representative selection of interdisciplinary field investigations, to be adapted and modified for individual instructional needs. Please feel free to make copies of the data tables provided herein for individual field investigations. We ask only that you give proper citation.

Acknowledgements: We gratefully acknowledge the many coastal investigators whose field research on coasts over the past decades makes a compilation like this possible. Thanks also are due to Norma Ritz who typed the manuscript. We take full responsibility for any errors or misinterpretations that remain.

FIELD TECHNIQUES: ATLANTIC BARRIER SYSTEM

When you finish this field exploration, you should be able to:

1. RECOGNIZE COASTAL MICROLANDFORMS IN THE FIELD -

   match the diagram to the beach;

2. MEASURE WATER PARAMETERS OF THE COAST FOR CALCULATIONS -

   obtain values for waves, tides and currents;

3. MEASURE THE BEACH SYSTEM FOR INTERACTIONS -

   record data for slope, topography, sediment, energy, minerals, scales, climate, and organisms;

4. MEASURE THE DUNE SYSTEM FOR COMPARISON -

   investigate depositional patterns, vegetation, landforms, topography, climate, soil, and social impacts:

5. MEASURE THE BAY - ESTUARINE SYSTEM FOR CONTRAST -

   collect data on the water, beach, organisms, sediment, minerals, and climate.

IMPACT: TAKE ONLY WHAT YOU NEED AND WILL USE FOR EDUCATIONAL PURPOSES

Science Education Methods:

1. PLANNING: activities for pre-planning, on-site, post-trip in class and lab;

2. INSTRUMENTS: home-made devices versus school-bought tools of the trade;

3. RECORDING: tables should be prepared ahead of time, to compensate for the wind, etc.;

4. SAMPLING: what do you want to do, and why, when, where, and how;

5. SAMPLES: how to collect, study, transport, and store them;

6. PERMISSIONS & CONFLICTING EVENTS: do your homework, call or write, respect property and the rules.

TOOLS TO ASSESS THE BARRIER SYSTEM

Stakes
String
Jackknife
Camera (Polaroid)
Sketch pad
Pencils
Clipboard
Measuring tape
Stopwatch
Wristwatch
Timer
Current floats
Dye
Wind meter
Thermometer
Soil thermometer
Protractor
Compass
Brunton compass
Topographic maps
Bathymetric charts
Seine
Wet Suits
Measured poles
Rope
Shovels (long & short handle)
Mason's plaster trowel
Sling Psychrometer
Abney or Locke level
Tripod or Jacob's staff
Sheath knife
2" x 4" x 2'
Sledge hammer
Modified bumper jack
Gas main sealer

5' & 10' ABS plastic pipe (2" I.D.)
Hacksaw
Oakfield soil auger
Soil pH kit
Munsell color charts
Light meter
Rulers
Calculators
Meter sticks
Hand levels
Flag tape
Masking tape
Scotch tape
Baggies
Sample containers
Labels
Grease pens
Felt tip pens
Core tubes
Sieves
Hand lens (magnifying glass)
Binoculars
Towel
Canteen of water
3" x 5" index cards
First aid kit
Bug repellent (?)
Cheesecloth
Styrofoam sheets or cardboard
Aluminum foil
Elmer's glue
Rubber cement
Tuna cans
35 mm film canisters

Sediment size chart
Sediment shape chart
Mineral chart
Vegetation chart
Organisms chart
Beaufort wind scale
Graph paper
Coastal geomorphology chart
NOAA - NOA tide table
Wave direction calculator
Major dynamic zones chart
LEO data sheet
Cloud chart
Beach profile data sheet
USDA Soil Survey manual
Soil data sheets
AGI data sheets
Abiotic factors data sheet

FIELD INVESTIGATIONS AND ACCURACY

The accurate geologic characterization of a coastal zone involves at least four aspects: OBSERVATION, SAMPLING, SUBSEQUENT ANALYSIS, and WRITING, or SUMMARIZATION. Accuracy in each aspect is dependent upon thoughtful planning and practice in each phase. Throughout the entire characterization process, a uniformly high degree of care is necessary. Excessive care or accuracy in one aspect cannot cancel carelessness in another aspect, if meaningful results are to be obtained.

Observation

To be fruitful, geological observation requires:

1. Basic knowledge upon which questions may be formulated;

2. Concentration and attention to detail, balanced by an openmindedness to serendipity;

3. An ability to prioritize effort toward formulation of the "big picture" (hypothesis or model).

It is frequently desireable to first limit observations to a broad overview, to establish an orientation and allow for the formulation of major questions (both spontaneous and planned) to be studied. In this phase, it is instructive to identify areas broadly dominated by one particular geologic agent or another. These spatial designations, though tentative, serve as a first level ordering of the geological environment into process-dominant regions and provide direction to subsequent sampling and analysis. On site lists (inventories) and/or annotated photographs of notable process-distinctive features (i.e. a dune) and lists of potential questions for study, characterizing each process-region are a valuable approach toward fulfillment of the prerequisite familiarization and orientation process and provide further definition of the study area chosen for detailed study.

Sampling

Clearly, it is impossible to thoroughly characterize the contents of an entire geological landscape. A study area defined on the basis of notable process-distinctive features (landforms, or particular sediment distribution, or a vegetation association, etc.), or alternatively even an arbitrary rectangle, is most efficiently characterized by sampling. Although some students may lack statistical experience, familiarity with requisite sampling methods provides both a desirable foundation and underscores the need for scientific objectivity in data collection. Generally, this is accomplished by either of two methods: even intervals on a grid pattern, or randomly over an area and located by using a set of random numbers as reference coordinates to a grid shown in Figure 1.

Subsequent Analysis

Follow-up activities and discussions should be built into any field program. Recorded data should not lie fallow. Each field activity must be assessed to make certain that the student's data accurately portrays the processes and patterns evident along the coast.

Students profit most from a field experience, when there is opportunity for them to find their errors and false assumptions through comparisons between data and expected results. Their personal field effort is enhanced, when collected samples and data are cataloged for future use.

Opportunity should be made for students to appreciate the differences between theory and application: where procedures worked and where "it" did not function as planned. Have them list what they learned and compare their list with the objectives of the field study.

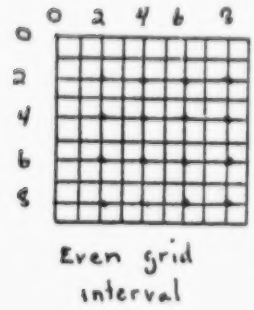
Writing or Summarization

Perhaps the most often under-utilized aspect of a field learning experience is the writing of some form of summarization of the findings. While lab reports are a common culmination to lab experiments, too frequently, written field study reports are rarely required. This void is unfortunate for both the highly involved budding young scientist and the practically oriented observer. Each profits measurably through the ordering of observation and thought that a written summary necessitates.

INSTRUMENTATION

Many schools do not have the funds to procure the necessary equipment required on earth sciences field trips. Discipline and management require that everyone be actively involved at all times. While we strongly recommend that you keep yelling for the necessary equipment to carry out your teaching mandate, we have included in this guide, a variety of simple devices that students can (and ought to) construct before the trip, through methods that require little or no cost. WHERE THERE IS A WAY, THERE IS A WILL (reverse psychology).

IF SOMEONE SAYS TO YOU THAT IT CANNOT BE DONE -
DO IT YOURSELF!



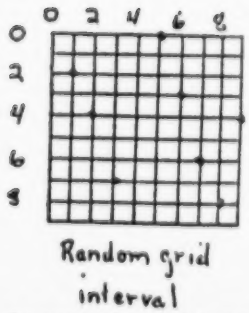


Figure 1 Grid systems.

Table 1 Random numbers. Each digit in this table is a random number, the digits 0–9 each having equal probabilities of occurrence.

72378	01405	95661	03420	78000	03584	89256	48148	54441	15006	75844
50353	53906	43341	96425	80011	80503	51820	08747	05310	09154	85027
40095	55564	77525	64382	13597	58097	02658	23665	47217	61670	67507
00672	32089	39260	21678	37862	51031	02383	94370	24767	62636	56282
05373	82265	01452	02664	95827	62541	57748	37788	98641	13074	59851
60211	29095	08662	78489	13400	80308	33724	66220	23324	65317	03088
63854	67504	26671	55107	28320	06115	20688	11712	78786	66667	09120
33219	69719	37049	06584	89301	23108	47587	97659	16735	85303	40863
19059	48330	18547	05172	25732	48938	25173	56544	18643	46562	56058
28028	91527	34880	65788	77156	40212	16872	30322	47825	78698	89286
95262	87260	10265	28031	15641	49008	44362	68420	44736	80945	54083
68371	81282	26282	66386	11234	40456	77640	20932	55145	09798	61267
02517	72647	53029	21456	12820	17858	53396	72542	56587	61588	30946
55912	42538	65268	87143	85820	73830	73762	84002	56484	19486	27427
32711	65041	93170	13614	17029	18270	75218	30374	09200	22651	76392
86583	45072	33471	45101	67867	21787	74746	37426	23953	43742	60724
04562	14705	32767	85383	43730	74666	62489	24164	42771	56411	55458
28192	88637	15307	88580	78652	79156	39632	62864	84734	10681	57011
47173	54956	75299	10605	07643	70394	58712	20736	12631	64566	81016
57943	37570	62821	50387	53128	38488	21570	61830	21384	86599	07684
33235	25578	47405	24712	14563	98587	94862	61568	52375	51258	03932
57567	66833	39346	30099	68204	09323	94646	05511	29860	57563	27556
12043	42767	17828	73918	05445	16253	10615	04136	82898	31182	07834
30287	81277	71234	51435	25285	21856	03944	05070	52557	66600	66672
54164	48823	28124	38875	08937	51087	31415	21947	67216	25701	10042
36307	71783	99230	88528	35911	28077	31027	51213	37553	00330	12540
28660	87182	65085	93923	60378	48456	24842	71311	44193	39467	27422
07107	55856	42467	46407	21451	76500	18655	88052	41108	19538	64092
11026	67355	54195	91122	55017	41382	84028	05463	26210	68635	44965
69610	54521	82653	64520	96323	92538	31232	51428	70460	78712	01378
72836	66023	50517	74013	85441	78707	00286	65630	11430	60014	26046
73090	58675	26463	56635	96127	10657	80076	40735	90560	27350	00610
47466	54451	81515	38197	24982	38376	91496	05080	51789	16501	54418
18207	41438	55220	55808	54785	47129	06123	87318	19685	53824	51234
52982	03033	01617	63932	36097	86389	21048	33319	98684	48544	41435

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LANDFORM COMPONENTS OF THE BEACH AND THEIR RELATIONSHIP TO SLOPE ANGLE, TIDE AND WAVES

A beach consists of the usually thick accumulation of loose wave-born material (sand, pebbles, mud and shell fragments) in active transit or temporary storage along the shore zone between the limits of high and low tide. Sometimes likened to a giant river of sand, four important factors constitute what comprises a beach area:

1. the kind of material that is found;
2. the inner or landward limit;
3. the outer or seaward limit;
4. the energy available.

Purpose:

To acquaint students with the component systems of the beach area, familiarize them with correct usage of coastal terminology and assist in delineation of the boundaries of the following groupings:

1. forms based upon tidal action (in the subtidal, intertidal and supra tidal zone)
   a. BERM - separates the supratidal zone from the intertidal zone;
   b. SPILLOVER POOLS - may occur in the supratidal zone;
   c. RIDGES AND RUNNELS [1] (hill and valley microrelief) occur in the intertidal zone.

2. forms based upon wave action (breaker and surf zones and zone of swash and backwash
   a. BARS AND TROUGHS - submerged offshore highs and lows;
   b. BEACHFACE - the sloping section of the beach exposed to the action of wave uprush

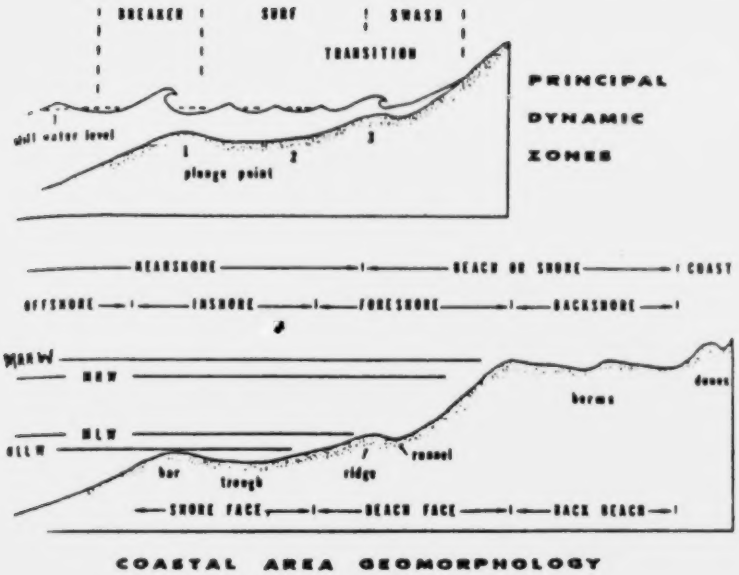
Materials:

Coastal Geomorphology Chart, glossary of terms, stakes, measuring tape

Procedure:

1. Define the observable boundaries and place a scientific name on each. Measure the width and average slope of the zones between the boundaries. Using the landform chart, apply names to each zone (you also may wish to refer to p. 19)
2. Sketch and label your own general beach landform profile for this location. Repeat this process at the same traverse every three hours and compare the scaled profiles. Which zones increase or decrease? What conditions seem to be related to the observed increase or decrease in the zones?

1. Swales are large valleys or depressions in dune fields.



COASTAL AREA GEOMORPHOLOGY

FIG. 2.—Coastal geomorphological terminology and principal dynamic zones.

Table 2

Beaufort Wind Scale

No.	*Description of Wind Effect*	*Equivalent in Knots* (1 knot = 1.15 mph.)
0	Smoke rises vertically	less than 1
1	Wind direction shown by smoke drift but not by wind vane	1-3
2	Wind felt on face; leaves rustle; vane moved by wind	4-6
3	Leaves and small twigs in constant motion; wind extends light flag	7-10
4	Raises dust and loose paper; small branches are moved	11-16
5	Small trees in leaf begin to sway; crested wavelets form on inland water	17-21
6	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	22-27
7	Whole trees in motion; inconvenience felt in walking against wind	28-33
8	Breaks twigs off trees; generally impedes progress in walking against wind	34-40
9	Slight structural damage occurs; chimney pots and slate removed	41-47
10	Seldom experienced inland; trees uprooted; considerable damage occurs	48-55
11	Very rarely experienced; widespread damage	56-63
12	Hurricane force	above 63

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TIDAL CYCLE ANALYSIS

The tidal cycle is an important factor in the barrier environment especially, as an energy system with opposing currents and vertical range (or horizontal submergence-emergence), on a semidiurnal basis, as is characteristic for the Atlantic. Time of the movement in addition to the volume and height of the water moved is critical. Although this dynamic system has a predictable cycle, it occurs at different times daily and is site specific. In a barrier system, the ocean tidal cycle may be hours out of synchronization with the backbay tidal sequences.

TIDES WAIT FOR NO MAN OR WOMAN!

Tidal calculations for the site should be performed before the trip, so field time and land exposure is effectively utilized. The tidal process is extremely critical for the beach marsh processes. Each segment of the tidal cycle should be measured and observed. Tidal currents are easy to measure on marshes and inlets (ebb, flood, slack) but the beach investigations yield up/down and in/out movement of the water.

Purpose:

To measure the rate of the vertical rise and fall of the tidewater (tidal range), and record beachface changes in form with the in and out (horizontal scale) movement of the water.

A. Tidal Currents on the Atlantic Beaches

Materials:

NOAA-NOA Tide Tables and adjustments for the area (see Figure 3), 10-20 numbered and scaled stakes or poles (1 1/2 meter length), watch or alarm clock (set for 10-15 minute intervals, eg. cooking timer), prepared data table for recording pole readings.

Procedures:

Pre-trip: calculate and graph the tidal cycle for the site on the trip day.

APRIL 28, 1984

TIME	HEIGHT
00 33	.2 - .1
06 48	3.9 1.2
12 48	.2 .1
19 04	4.2 1.3

HOMEWORK

1. Change time to AM, PM
2. Select high water and low water from height data
3. Calculate the tidal range (H-L) for the day
4. Determine the period of ebb tidal current
5. Determine the period of flood tidal current
6. Plot a curve from the data (time vs. height in 24 hrs. Label the parts of the cycle (See Figure 4)

Figure 3 Times and Heights of High and Low Waters

BREAKWATER HARBOR, DEL., 1984

Times and Heights of High and Low Waters

APRIL

Day	Time	Height		Day	Time	Height	
	h m	ft	m		h m	ft	m
1 Su	0218	-0.2	-0.1	16 M	0235	-0.9	-0.3
	0834	4.2	1.3		0852	4.6	1.4
	1433	0.0	0.0		1445	-0.7	-0.2
	2047	4.2	1.3		2112	5.3	1.6
2 M	0252	-0.2	-0.1	17 Tu	0326	-0.8	-0.2
	0909	4.1	1.2		0941	4.4	1.3
	1503	0.0	0.0		1530	-0.6	-0.2
	2121	4.4	1.3		2200	5.3	1.6
3 Tu	0328	-0.2	-0.1	18 W	0415	-0.7	-0.2
	0942	3.9	1.2		1027	4.1	1.2
	1534	0.0	0.0		1616	-0.4	-0.1
	2156	4.4	1.3		2246	5.1	1.6
4 W	0406	-0.1	0.0	19 Th	0508	-0.4	-0.1
	1019	3.8	1.2		1115	3.8	1.2
	1609	0.1	0.0		1703	-0.1	0.0
	2235	4.4	1.3		2335	4.8	1.5
5 Th	0448	0.0	0.0	20 F	0601	-0.1	0.0
	1057	3.6	1.1		1205	3.5	1.1
	1646	0.1	0.0		1754	0.2	0.1
	2314	4.4	1.3				
6 F	0532	0.1	0.0	21 Sa	0028	4.5	1.4
	1141	3.4	1.0		0658	0.2	0.1
	1728	0.2	0.1		1301	3.3	1.0
					1851	0.5	0.2
7 Sa	0002	4.4	1.3	22 Su	0124	4.2	1.3
	0624	0.2	0.1		0800	0.5	0.2
	1228	3.3	1.0		1401	3.1	0.9
	1818	0.3	0.1		1951	0.7	0.2
8 Su	0055	4.3	1.3	23 M	0227	4.0	1.2
	0721	0.4	0.1		0901	0.6	0.2
	1328	3.2	1.0		1506	3.1	0.9
	1917	0.4	0.1		2057	0.7	0.2
9 M	0200	4.3	1.3	24 Tu	0332	3.9	1.2
	0827	0.4	0.1		1001	0.6	0.2
	1434	3.2	1.0		1609	3.2	1.0
	2028	0.3	0.1		2202	0.7	0.2
10 Tu	0309	4.3	1.3	25 W	0431	3.9	1.2
	0935	0.3	0.1		1053	0.6	0.2
	1545	3.3	1.0		1702	3.4	1.0
	2139	0.2	0.1		2259	0.6	0.2
11 W	0417	4.4	1.3	26 Th	0523	3.9	1.2
	1038	0.1	0.0		1136	0.5	0.2
	1654	3.7	1.1		1750	3.7	1.1
	2247	-0.1	0.0		2350	0.4	0.1
12 Th	0523	4.6	1.4	27 F	0608	3.9	1.2
	1134	-0.2	-0.1		1214	0.4	0.1
	1753	4.1	1.2		1828	3.9	1.2
	2350	-0.4	-0.1				
13 F	0619	4.7	1.4	28 Sa	0033	0.2	0.1
	1227	-0.5	-0.2		0648	3.9	1.2
	1848	4.5	1.4		1248	0.2	0.1
					1904	4.2	1.3
14 Sa	0048	-0.6	-0.2	29 Su	0114	0.1	0.0
	0714	4.8	1.5		0726	3.9	1.2
	1314	-0.7	-0.2		1320	0.1	0.0
	1938	4.9	1.5		1939	4.4	1.3
15 Su	0142	-0.8	-0.2	30 M	0151	0.0	0.0
	0804	4.7	1.4		0803	3.9	1.2
	1400	-0.7	-0.2		1353	0.1	0.0
	2026	5.2	1.6		2016	4.6	1.4

MAY

Day	Time	Height		Day	Time	Height	
	h m	ft	m		h m	ft	m
1 Tu	0230	-0.1	0.0	16 W	0312	-0.6	-0.2
	0840	3.9	1.2		0919	4.0	1.2
	1425	0.0	0.0		1503	-0.4	-0.1
	2053	4.7	1.4		2138	5.3	1.6
2 W	0307	-0.2	-0.1	17 Th	0359	-0.5	-0.2
	0918	3.8	1.2		1007	3.8	1.2
	1502	0.0	0.0		1549	-0.2	-0.1
	2130	4.8	1.5		2224	5.1	1.6
3 Th	0349	-0.1	0.0	18 F	0450	-0.2	-0.1
	0955	3.7	1.1		1053	3.6	1.1
	1539	0.1	0.0		1635	0.1	0.0
	2212	4.8	1.5		2311	4.8	1.5
4 F	0431	-0.1	0.0	19 Sa	0538	0.0	0.0
	1039	3.5	1.1		1143	3.4	1.0
	1621	0.1	0.0		1727	0.3	0.1
	2255	4.7	1.4		2359	4.5	1.4
5 Sa	0517	0.0	0.0	20 Su	0631	0.2	0.1
	1124	3.4	1.0		1233	3.3	1.0
	1708	0.2	0.1		1820	0.5	0.2
	2344	4.6	1.4				
6 Su	0610	0.1	0.0	21 M	0050	4.2	1.3
	1217	3.3	1.0		0722	0.4	0.1
	1803	0.3	0.1		1327	3.2	1.0
					1916	0.7	0.2
7 M	0041	4.5	1.4	22 Tu	0145	4.0	1.2
	0708	0.2	0.1		0818	0.5	0.2
	1317	3.3	1.0		1424	3.2	1.0
	1904	0.4	0.1		2017	0.8	0.2
8 Tu	0142	4.4	1.3	23 W	0240	3.8	1.2
	0808	0.2	0.1		0909	0.6	0.2
	1424	3.4	1.0		1518	3.4	1.0
	2013	0.4	0.1		2119	0.8	0.2
9 W	0249	4.4	1.3	24 Th	0335	3.7	1.1
	0911	0.1	0.0		0957	0.6	0.2
	1531	3.7	1.1		1612	3.6	1.1
	2125	0.3	0.1		2218	0.7	0.2
10 Th	0355	4.3	1.3	25 F	0428	3.6	1.1
	1010	0.0	0.0		1041	0.5	0.2
	1634	4.0	1.2		1700	3.8	1.2
	2233	0.0	0.0		2310	0.5	0.2
11 F	0459	4.3	1.3	26 Sa	0518	3.6	1.1
	1105	-0.2	-0.1		1121	0.4	0.1
	1734	4.5	1.4		1743	4.1	1.2
	2337	-0.2	-0.1		2358	0.4	0.1
12 Sa	0558	4.3	1.3	27 Su	0601	3.6	1.1
	1158	-0.4	-0.1		1158	0.3	0.1
	1827	4.8	1.5		1825	4.4	1.3
13 Su	0035	-0.4	-0.1	28 M	0043	0.2	0.1
	0652	4.3	1.3		0648	3.6	1.1
	1245	-0.5	-0.2		1235	0.2	0.1
	1918	5.2	1.6		1905	4.6	1.4
14 M	0130	-0.6	-0.2	29 Tu	0124	0.0	0.0
	0744	4.2	1.3		0729	3.6	1.1
	1333	-0.6	-0.2		1314	0.1	0.0
	2006	5.3	1.6		1947	4.8	1.5
15 Tu	0220	-0.7	-0.2	30 W	0205	-0.1	0.0
	0833	4.1	1.2		0811	3.6	1.1
	1418	-0.5	-0.2		1352	0.0	0.0
	2052	5.4	1.6		2026	4.9	1.5
				31 Th	0247	-0.2	-0.1
					0853	3.6	1.1
					1433	-0.1	0.0
					2110	5.0	1.5

JUNE

Day	Time	Height		Day	Time	Height	
	h m	ft	m		h m	ft	m
1 F	0330	-0.2	-0.1	16 Sa	0429	-0.1	0.0
	0938	3.6	1.1		1032	3.5	1.1
	1519	-0.1	0.0		1613	0.1	0.0
	2156	5.0	1.5		2248	4.7	1.4
2 Sa	0416	-0.2	-0.1	17 Su	0513	0.0	0.0
	1024	3.5	1.1		1115	3.4	1.0
	1605	0.0	0.0		1701	0.3	0.1
	2242	5.0	1.5		2330	4.5	1.4
3 Su	0505	-0.2	-0.1	18 M	0557	0.2	0.1
	1112	3.5	1.1		1201	3.4	1.0
	1656	0.0	0.0		1749	0.5	0.2
	2333	4.9	1.5				
4 M	0557	-0.1	0.0	19 Tu	0015	4.3	1.3
	1207	3.5	1.1		0644	0.3	0.1
	1753	0.1	0.0		1247	3.4	1.0
					1839	0.6	0.2
5 Tu	0028	4.7	1.4	20 W	0101	4.0	1.2
	0652	-0.1	0.0		0727	0.4	0.1
	1307	3.6	1.1		1337	3.4	1.0
	1854	0.2	0.1		1934	0.7	0.2
6 W	0124	4.5	1.4	21 Th	0150	3.8	1.2
	0748	-0.1	0.0		0812	0.5	0.2
	1410	3.8	1.2		1430	3.5	1.1
	2003	0.3	0.1		2032	0.8	0.2
7 Th	0227	4.3	1.3	22 F	0240	3.6	1.1
	0846	-0.1	0.0		0857	0.6	0.2
	1514	4.0	1.2		1519	3.7	1.1
	2112	0.2	0.1		2130	0.7	0.2
8 F	0331	4.1	1.2	23 Sa	0331	3.5	1.1
	0942	-0.2	-0.1		0940	0.5	0.2
	1615	4.3	1.3		1609	3.9	1.2
	2220	0.1	0.0		2225	0.6	0.2
9 Sa	0435	4.0	1.2	24 Su	0426	3.4	1.0
	1036	-0.2	-0.1		1026	0.4	0.1
	1713	4.7	1.4		1657	4.2	1.3
	2324	0.0	0.0		2318	0.5	0.2
10 Su	0534	3.9	1.2	25 M	0515	3.4	1.0
	1129	-0.3	-0.1		1110	0.3	0.1
	1808	4.9	1.5		1745	4.4	1.3
11 M	0023	-0.2	-0.1	26 Tu	0008	0.3	0.1
	0632	3.8	1.2		0608	3.4	1.0
	1219	-0.3	-0.1		1155	0.2	0.1
	1900	5.1	1.6		1832	4.7	1.4
12 Tu	0117	-0.3	-0.1	27 W	0054	0.1	0.0
	0725	3.8	1.2		0656	3.4	1.0
	1306	-0.3	-0.1		1240	0.0	0.0
	1947	5.2	1.6		1918	4.9	1.5
13 W	0208	-0.4	-0.1	28 Th	0141	-0.1	0.0
	0815	3.7	1.1		0744	3.5	1.1
	1355	-0.3	-0.1		1326	-0.1	0.0
	2034	5.2	1.6		2005	5.1	1.6
14 Th	0257	-0.3	-0.1	29 F	0226	-0.2	-0.1
	0901	3.6	1.1		0831	3.6	1.1
	1441	-0.2	-0.1		1412	-0.2	-0.1
	2119	5.1	1.6		2052	5.2	1.6
15 F	0343	-0.3	-0.1	30 Sa	0313	-0.3	-0.1
	0947	3.6	1.1		0918	3.7	1.1
	1527	0.0	0.0		1501	-0.3	-0.1
	2203	5.0	1.5		2140	5.2	1.6

Time meridian 75° W. 0000 is midnight. 1200 is noon.
Heights are referred to mean low water which is the chart datum of soundings.

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Field:

1. Set out stakes perpendicular to the beach from the dry high tide area to the water's edge (See Figure 5).

NOTE 1: If an ebb segment is being observed, add one stake or more, per fifteen minutes at the new water edge.

NOTE 2: If a flood segment is being observed, make sure the stakes or poles are deep enough to sustain both the flood current and wave action, and that they are tall enough to record the height of rise.

RECORDS FROM THE AREA WILL TELL YOU THE TIDAL RANGE NECESSARY FOR THE POLE LENGTH. Lewes tide range is 4 ft.

NOTE 3: If poles or stakes are not placed at standard set intervals (1 to 5 meters), make sure to record the horizontal distance between each pole segment.

2. Record the water rise (or fall) at each stake or pole at a set interval of time (10/1 See Figure 6). Between each set of stakes, record what happens to the beach, energy, waves, organisms, etc., for the entire period of rise and fall of the tide. If a pit is dug near the high tide limit, tidal fluctuations may also be measured by the ground water table rise and fall. A meter stick placed in a trench dug to the water table will allow periodic readings. Place a stick deep enough to record the total fall. This should be accomplished in concurrence with the trenching activity (refer to p24).

NOTE: All poles or stakes in the intertidal zone should have the same total height or adjustments should be calculated.

B. Tidal Currents on the Bay side:

Materials:

Tide tables, stopwatch or timer, tidal current meter (homemade), compass or map, controlled floats (constructed as indicated in the procedure).

Procedure:

1. Measure the current direction by observing floating material or watching the tilt of the buoys. Determine which tidal cycle you are observing (ebb is out-going, flood is incoming, slack is dead water). Direction provides a clue to the tidal segment, however a map showing the outlet for the bay, or position of the inlet, is needed for accuracy.

2. Place a controlled float (one that is wind resistant), into the water to measure the current velocity. Time the current flow over a set distance.

Velocity (v) = distance/time or d/t in meters/second

NOTE: To construct a float, obtain a plastic litre soda bottle with a cap. Partially fill the bottle with water to dampen wind force and tie a suitable piece of string on the end for retrival.

3. Measure the tidal current every hour from high or low water times (e.g. 6:48 on the 29th) and record the speed, direction, and time interval. Upon returning to class, plot this data (time vs. speed) and compare the results with the pretrip graph (use arrows to illustrate ebb and flood

directions). Because the energy and duration of the ebb and flood currents are rarely equal, determine which one is more prominent for the study area. Was the stronger current predictable from the tide data?

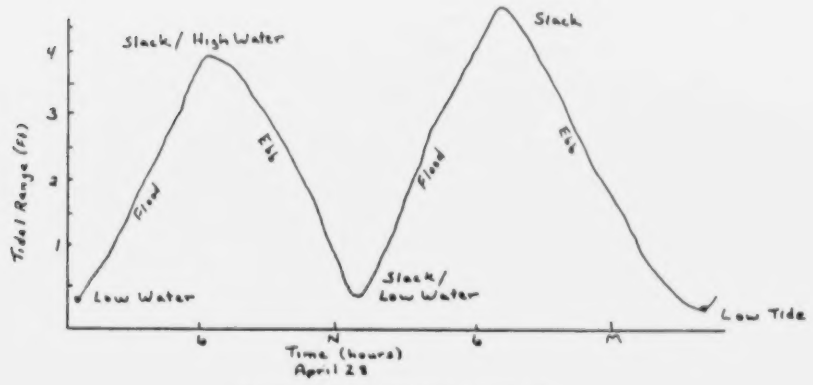

Figure 4 Tidal Cycle.

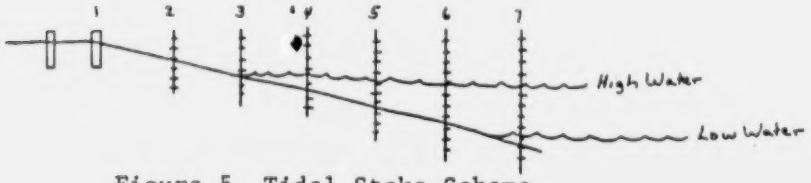

Figure 5 Tidal Stake Scheme.

	Land			Poles				Ocean		
	1	2	3	4	5	6	7	8	9	Remarks
Initial Depth										
1. Time:										
2. Time:										
3. Time:										
4. Time:										
5. Time:										
6. Time:										
7. Time:										
8. Time:										
9. Time:										
10. Time:										

Figure 6 Beach Tidal Record.

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LITTORAL ENVIRONMENTAL OBSERVATIONS (LEO)

The U.S. Army Corps of Engineers was charged with the organized assessment of our coastal waters a few years ago. The result of that mandate was a standard government form designed so that observers would collect the same data. LEO is the nickname for this computer data form. It was also an attempt to start a long range data collection program for our coasts, so that seasonal and storm variations could be monitored for select parameters.

Purpose:

To develop familiarity and skill in using the LEO inventory assessment method of data collection.

Materials:

Wave direction calculator, major dynamic zones chart, LEO data sheet

Procedure:

Complete the LEO form as directed.

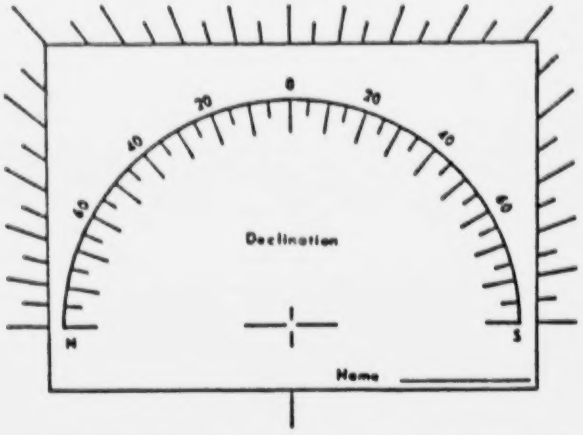


Figure 7 Wave Direction Calculator.

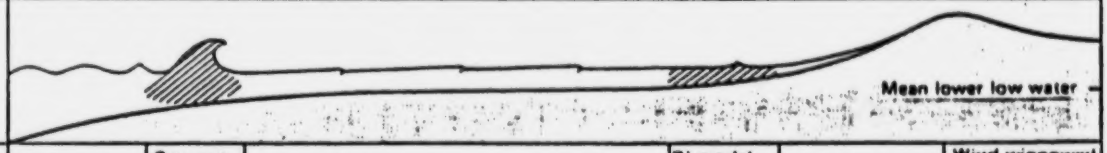
WATER MOTION	Oscillatory Waves	Wave Collapse	Waves of Translation (bores): Longshore Currents: Seaward Return Flow; Rip Currents	Collision	Swash; Backwash	Wind
DYNAMIC ZONE	Offshore	Breaker	Surf	Transition	Swash	Berm Crest
PROFILE						
SEDIMENT SIZE TRENDS	— Coarser →	Coarsest Grains	← Coarser	Bi modal Lag deposit	← Coarser —	Wind winnowed lag deposit
PREDOMINANT ACTION	Accretion	Erosion	Transportation	Erosion	Accretion and Erosion	
SORTING	← Better —	Poor	Mixed	Poor	— Better →	
ENERGY	— Increase →	High	— Gradient →	High		

Figure 8 Major dynamic zones in the nearshore zone of a sandy coast. Two regions of maximum sand suspension and transport are shaded. (Ingle, 1966, Fig. 116.)

Table 3 LEO Form.

LITTORAL ENVIRONMENT OBSERVATIONS

RECORD ALL DATA CAREFULLY AND LEGIBLY

SITE NUMBERS (1 2 3 4 5) | YEAR (6 7) | MONTH (8 9) | DAY (10 11) | TIME (12 13 14 15)

Record time using the 24 hour system.

WAVE PERIOD (16 17 18)

Record the time in seconds for eleven (11) wave crests to pass a stationary point. If calm record 0.

WAVE HEIGHT (19 20 . 21)

Record the best estimate of the average wave height to the nearest tenth of a foot.

WAVE ANGLE AT BREAKER (22 23 24)

Record to the nearest degree the direction the waves are coming from using the protractor on the reverse side.

Fig: G

WAVE TYPE (25)

0 – Calm
1 – Spilling
2 – Plunging
3 – Surging
4 – Spill / Plunge

WIND SPEED (26 27)

Record wind speed to the nearest mph. If calm record 0.

WIND DIRECTION – (28)

Direction the wind is coming from

1 – N 3 – E 5 – S 7 – W 0 – Calm
2 – NE 4 – SE 6 – SW 8 – NW

FORESHORE SLOPE (29 30)

Record foreshore slope to the nearest degree.

WIDTH OF SURF ZONE (31 32 33 34)

Estimate in feet the distance from shore to breakers, if calm record 0.

LONGSHORE CURRENT

DYE (35 36 37 38)

Estimate distance in feet from shoreline to point of dye injection.

CURRENT SPEED (43 44 45)

Measure in feet the distance the dye patch is observed to move during a one (1) minute period; if no longshore movement record 0.

CURRENT DIRECTION (46 47)

0 No longshore movement
+1 Dye moves toward right
–1 Dye moves toward left

RIP CURRENTS (48 49 50 51 52)

If rip currents are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no rips record 0.

BEACH CUSPS (53 54 55 56)

If cusps are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no cusps record 0.

PLEASE PRINT:

SITE NAME _____ OBSERVER _____

Please Check The Form For Completeness

REMARKS: _____

CERC 113-72
8 Dec 72

Make any additional remarks, computations or sketches on the reverse side of this form.

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Waves and Breakers: Concepts and Terminology In Brief.

A. Waves of Oscillation. Oscillatory waves occur as a result of a transfer of momentum from the horizontal movement of air (wind) across a water surface in deep water. As the air passes over the water surface, an orbital motion is induced in the water by the drag forces in the air. As the water parcels move in circular paths, two things result: (1) there is a gradual transfer of this orbital motion downward to depths equal to ½ the wavelength, and (2) the form of the wave moves forward as ripples formed by wind in a wheat field.

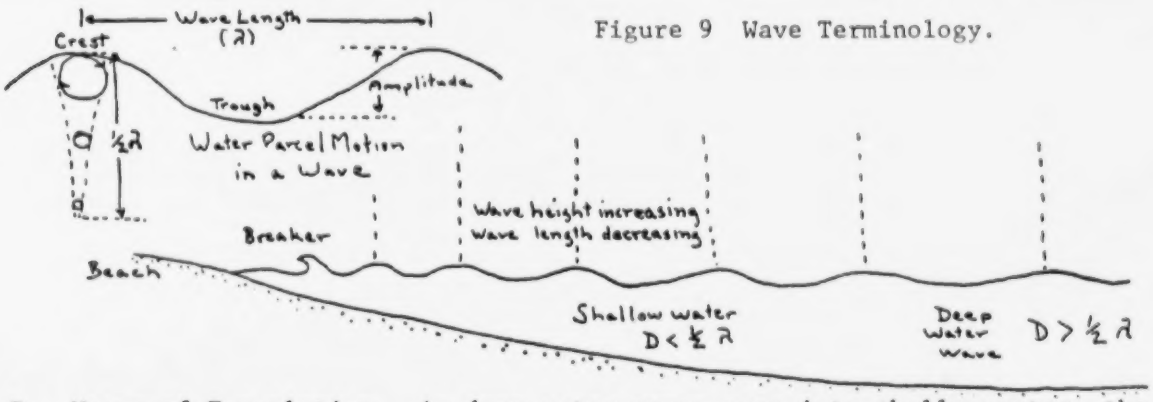

Figure 9 Wave Terminology.

B. Waves of Translation. As deep water waves pass into shallow water, the wave form changes noticeably. As orbital motion of the water gets closer to the shoaling bottom, the increase in relative water velocity increases the bouyant effect of water on the bottom sediment. In turn, the increased traction load of sediment tends to slow the moving water near the bottom of the orbital cycle, while the upper cycle is less affected. Gradually, as depth decreases, the shape of the path of the water parcels changes from circular oscillatory motion to eccentric motion. The wave crests peak up and progressively become more unstable, as more water amasses in the wave crests, than can be supported by the water in the adjacent troughs. Eventually, the wave spills or breaks into the trough under the influence of gravity. Oscillatory motion translates into horizontal motion, sediment bouyancy is interrupted and some deposition occurs until a new wave is formed.

Terminology.

1. Wave length (L) - distance from crest to crest or trough to trough
2. Wave height (H) - vertical distance from trough to crest
3. Period (T) - time interval between passage of successive wave crests
4. Velocity (C) - direction and speed at which a wave travels L/T or Lf
5. Frequency (f) - the reciprocal of the wave period f = 1/T

Types of Breakers.

1. Plunging - wave curls over in a half cylinder and crashes with a roar
2. Spilling - crest foams over and cascades down the front of the wave
3. Surging - wave occurs on very steep beach faces as a pronounced uprush and backrush

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LONGSHORE CURRENT DIRECTION AND VELOCITY

Wave refraction generates currents flowing along the shore from headlands where the breakers are focused, to adjacent stretches where the water level is lower. These wave generated currents are called longshore or littoral currents and transport the sediment from the hedlands to (and along) the beach face until the current velocity decreases and a spit is built.

Purpose:

To determine the direction and width of the longshore transport zone.

Materials:

Five to 10 floats (plastic soda bottles), stop watch or timer, rescue dye (safe, non-toxic, bright color)

Procedure:

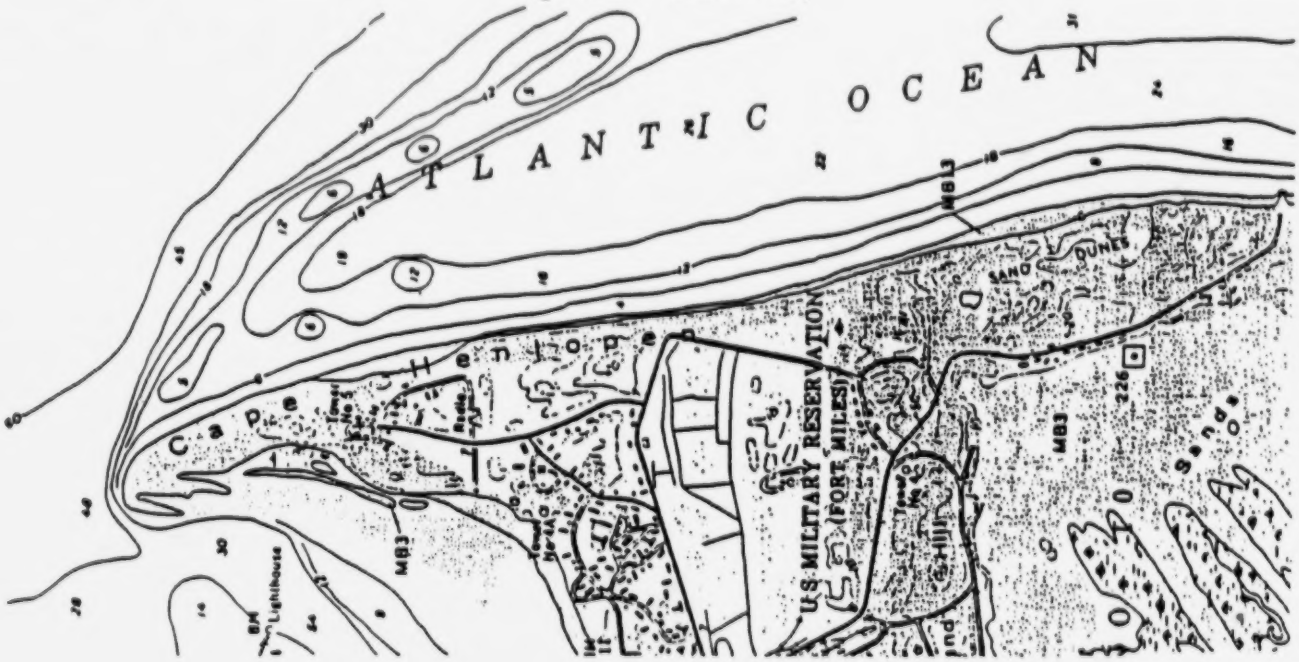
1. Establish a zero point in the swash zone and mark it with a stake. Release 5 to 10 floats in the water (edge). Measure their movement every minute for 10 minutes, then plot your results on the coastal map provided.

2. Repeat this technique in the surf and breaker zones.

3. Prepare the dye packet for release into the water. Use the same zero point as the float experiment. Release (throw or other method) the dye seaward beyond the breaker zone. Record the movement and direction as above.

4. Repeat the above procedure for measuring tidal currents in the bay.

Figure 10 Coastal Map



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RAPID SEDIMENT SAMPLING ANALYSIS

Why look at sediment on the beach? Detailed analysis of collected samples is given later in the guide (p. 24), but many times a quick look to gain an impression of the beach sediment is necessary.

Purpose:

To become familiar with a variety of quick sediment sampling methods.

Materials:

Clear Scotch tape, model glue, hand lens, 3 x 5 index cards, AGI Data Sheets

Procedure:

A. Wet Finger Method. Wet your finger and touch it to the sand surface. With a handlens, assess the color, shape and size for each of the grains on your finger. Repeat this process, using a different finger for each of the major beach zones. Record the observations for size, shape and color for comparison. Note: right-handed students should use their left hand for sampling and record observations with their right -- lefties reverse the process.

B. Giant Pinch or Small Scoop Method. Place a random pinch or scoop of beach grains into your palm and spread them out so that there are no piles (discard the excess back to the beach). Assess the color, shape and size of the grains with a hand lens. Repeat and record your observations for each beach zone or measured interval.

C. American Geological Institute Data Sheet Method. Place the sample in the circle on Figure and determine the size, color, and shape, as well as the percent occurrence of each category. In windy conditions, place the sample in a small glass covered dish (petri dish). Samples sized by this method, may be used to construct a grain size chart using a file card and Scotch tape or model glue. Alternatively, some samples may be coded to create a visual Power's shape chart using another file card and tape or glue.

Note: material composition varies from mineral grains to rock fragments, skeletal debris and human fill.

Figure 11 Graph For Determining Particle Size.

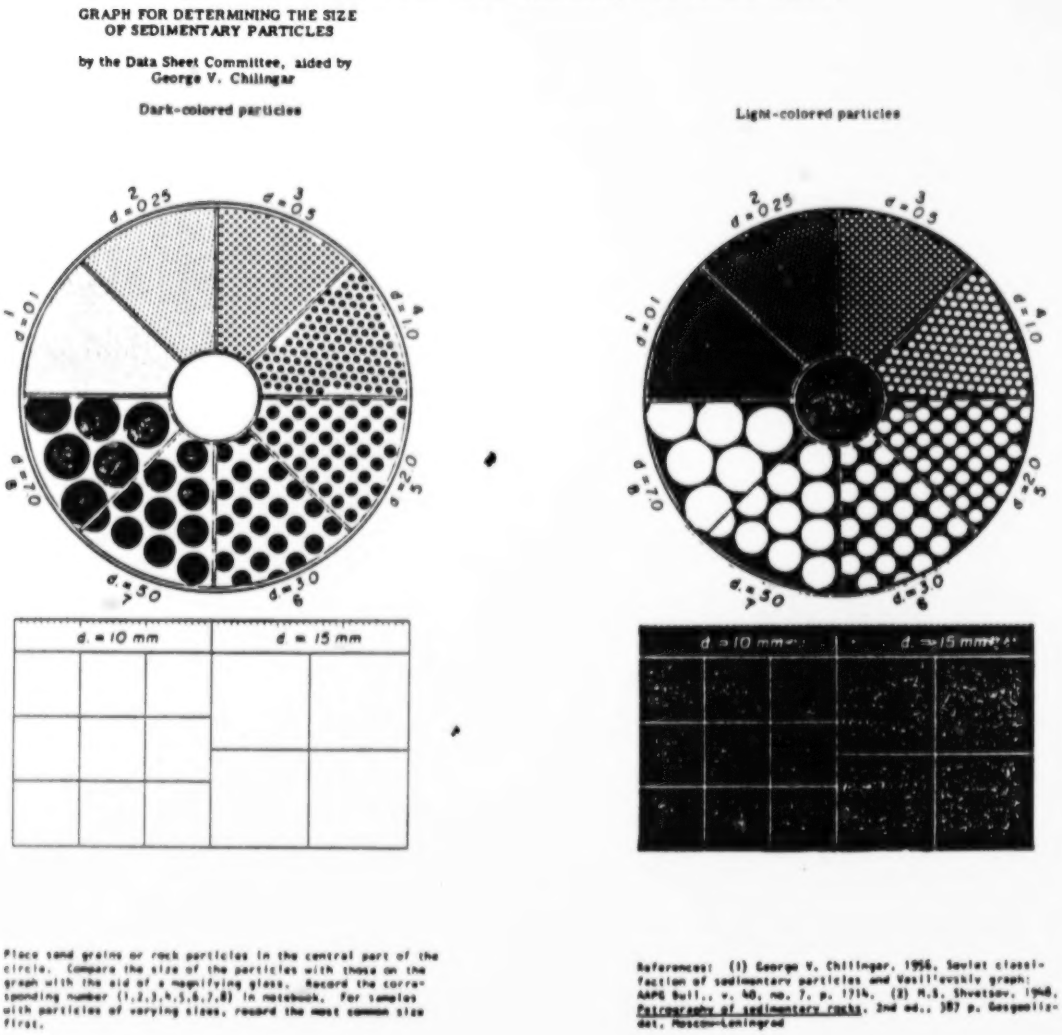
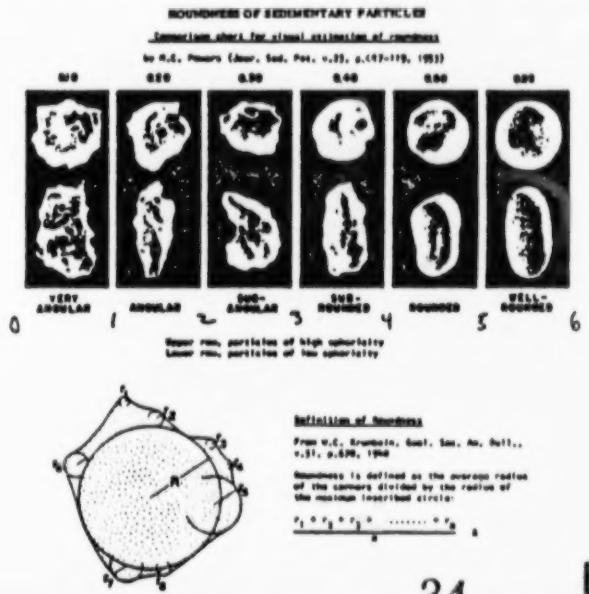

GRAPH FOR DETERMINING THE SIZE OF SEDIMENTARY PARTICLES
by the Data Sheet Committee, aided by George V. Chilingar
Dark-colored particles
Light-colored particles
d = 10 mm
d = 15 mm
Place sand grains or rock particles in the central part of the circle. Compare the size of the particles with those on the graph with the aid of a magnifying glass. Record the corresponding number (1,2,3,4,5,6,7,8) in notebook. For samples with particles of varying sizes, record the most common size first.
References: (1) George V. Chilingar, 1956, Soviet classification of sedimentary particles and Vasil'yevskiy graph: AAPG Bull., v. 40, no. 7, p. 1714. (2) M.S. Shvetsov, 1948, Petrography of sedimentary rocks, 2nd ed., 387 p. Gosgeoltekhizdat, Moscow-Leningrad

Figure 12 Power's Shape Chart



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SEDIMENT PEELS

How do you collect soft materials and return delicate structures back to the laboratory? Peels are an important technique to aid in describing sedimentary structures like cross-bedding or bioturbation. Peels of coal balls or limestones allow study of vertical surfaces under the microscope. Peels of more dissaggregated materials, as found in dunes or vertical beach or river profiles, provide a way of bringing these microenvironmental processes back to the lab as casts. There are numerous methods and materials used to make peels: tape, glue, cement, plaster, and aluminum foil. Failure in making a useable peel is high and commonly causes much frustration for the time invested.

Purpose:

To attempt a variety of peels using different materials to experience the procedure, time and value of the final product.

Materials:

Shovel, cake knife or cleaning blade or mason's plaster trowel, cheesecloth, Elmer's glue, rubber cement, acrylic spray, styrofoam or cardboard, tape, foil

Procedure:

Obtain permission to study dunes in the area of study.

A. Glue and Cheesecloth Method. Find a dune exposure that illustrates good cross-beds and carefully clean off a flat vertical face. Cut a suitable (manageable) piece of cheesecloth and spray the face with acrylic spray, saturating the face thoroughly. Apply the cheesecloth to the sand face and carefully press it into the surface. Spray the cheesecloth with acrylic. Cover the cheesecloth with styrofoam or cardboard, brace the cover and let everything dry for many hours. When the peel has dried thoroughly, remove the protective cover and peel back the cheesecloth slowly and carefully. Coat the peel with a thin layer of Elmer's glue and mount it on cardboard or styrofoam. Transport the mounted peel back to the lab in a cardboard box, packed with crumpled newspaper. This method may also be used in the beach face.

B. Tape Methods. Small strips of masking tape may yield a sticky peel of horizontal or vertical changes in grain size or composition. Press the tape against the exposure surface and peel back carefully.

Clear scotch tape should also be tried in the same manner as above. This tape may be preserved by placing another strip of equal size back-to-back, creating a tape "sandwich." This strip peel may be scaled and examined under the microscope as a long thin section. Be certain to label each peel according to its location in the exposed face and the date the sample was collected.

C. Aluminum Foil Method. In the tidal flats where ripples are prominent, aluminum foil provides a quick method to capture the size and shape of the ripples. Simply place the foil over the rippled surface and smooth the foil to conform to the surface. Peel back carefully after determining the compass direction of the peel, so that the form of the ripples may be related to current or wave energy directions.

TEMPERATURE/CLIMATE

The climate of any area is a primary factor in most sedimentary processes. Soil surveys give the temperature and precipitation records but other patterns like wind or evapotranspiration are harder to observe. The regional daily, monthly, seasonal and annual climatic budgets should be reviewed before this field experience is undertaken.

Purpose:

To conduct field measurements on climate parameters and compare them to the standards in the record to determine if they are normal.

Materials:

Thermometers (air, soil), wind meters (speed, direction) records (Table 4), sling psychrometer, Beaufort scale, compass, sunrise/sunset chart, cloud identification chart, protractor.

Procedure:

1. Using a regular thermometer, record the air temperature every hour. Repeat this process for the seawater temperature and bay water temperature.

2. Using a soil thermometer, measure and record temperatures of the beach face and dune on an hourly basis. If you trench for a vertical profile, obtain the soil temperature at the top, middle and bottom of the trench and record both the temperature and the location of the sample in the profile. Also record the time for each reading.

3. Using your protractor and Brunton compass, track the path of the sun or moon (on suitable nights), recording both the altitude and azmuth if sky conditions permit. As an alternative, record the type, speed and direction of clouds for each hour in the field.

4. Using the hand held wind meter and Brunton compass, record the speed and direction of the wind plus any gusts that occur. Repeat this activity hourly. Relate the wind direction to the wave approach. If wind measuring equipment is not available, try calculating the wind using the Beaufort Scale provided (Table 2).

SUSSEX COUNTY, DELAWARE

TABLE 4.—*Temperature and precipitation, Bridgeville, Del.*

[Elevation: 50 feet. Period of record: 1931–60, unless otherwise indicated]

Month	Temperature: Average daily maximum	Temperature: Average daily minimum	Temperature: Two years in 10 will have at least 4 days with—[1] Maximum temperature equal to or higher than—	Temperature: Two years in 10 will have at least 4 days with—[1] Minimum temperature equal to or lower than—	Precipitation: Average total	Precipitation: One year in 10 will have— Less than—	Precipitation: One year in 10 will have— More than—	Precipitation: Days with snow cover 1 inch or more[2]	Precipitation: Average depth of snow on days with snow cover 1 inch or more[2]
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	45.9	27.1	65	13	3.54	1.5	6.7	4	3
February	47.4	26.8	66	14	2.89	1.6	4.4	4	3
March	54.5	32.7	71	19	3.98	1.9	6.1	2	4
April	65.7	41.5	83	30	3.43	2.1	4.9	----------	----------
May	75.7	51.6	87	39	3.78	1.3	6.8	----------	----------
June	83.8	60.5	93	45	3.60	1.6	5.9	----------	----------
July	87.3	65.1	95	55	5.06	2.0	10.2	----------	----------
August	85.5	63.5	94	51	5.55	2.0	11.4	----------	----------
September	79.9	56.9	90	43	4.02	1.0	8.8	----------	----------
October	69.9	46.1	83	34	3.19	1.4	6.3	----------	----------
November	58.7	36.3	72	24	3.21	1.2	5.3	(3)	----------
December	47.6	27.9	64	14	3.03	1.4	5.0	3	3
Year	66.8	44.7	[4] 98	[5] 5	43.28	30.5	53.2	13	3

[1] Period of record 1946–60.
[2] Period of record 1941–70.
[3] Only one snowfall has been recorded in November; a total of 7 inches in 1967.
[4] Average annual maximum.
[5] Average annual minimum.

Table 5 Temperature/Climate Data Sheet

Time	Temperature	Environment	Cloud Type	Wind Speed	Wind Direction

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BEACH PROFILING

In a geologic study of coastal dynamics, perhaps no activity is of more fundamental importance than the construction of a slope (beach) profile. From this activity, we not only develop skill and precision in a variety of survey techniques, but also establish a basic model to which other field observations and data may be attached. As the resulting model is built, the variations noted in detail along the profile, often lead to questions and further observations of the integrating effects of processes producing the slope.

Of course one profile is only a beginning, a representation of one transect across the quasi-linear coastal zone, at one brief moment in geologic time. For greater precision in understanding coastal processes, profiles must be repeated over a period of time and along parallel transects, to build a 3-dimensional model of the coastal changes as they occur.

Purpose:

To determine the configuration of the backshore and foreshore region and produce a basic model to which additional observations may be added.

Materials:

Abney level, Brunton compass or line level, twine, 1-2 graduated rods, 1-2 meter sticks, 2 to 4 participants (a compass operator, recorder and one or more rodmen and chainmen. The rodman determines vertical change in elevation; the chainman determines distance between stations.)

Procedures:

A. Brunton Compass or Abney Level Method. Attach the Brunton compass to a tripod or Jacob staff and level the apparatus at station 0, just beyond the swash limit on the upper beach face (see Figures 13 through 16). If you are not using a tripod or staff, a pole of known length (5-6 ft.) may be used to steady the compass.

1. With the compass level, carefully determine the vertical height between the ground surface and the compass line of sight, and record this information on the data sheet. The recorder may initially need to assist the compass operator in keeping the compass level.

2. To include the slope of the beach face in your profile, one rodman with an increment pole (or pole and tape measure) proceeds to station -1, perpendicular to the shoreline. At station -1 the vertical height between the line of sight and the ground surface is recorded, as well as the true ground distance between station 0 and -1. It may be necessary to repeat measurements recorded at station -1 seaward if the beach face is particularly dedicated and adventurous. (Be prepared to get wet while obtaining this information to record in the data table. You will need to dry the tape measure prior to continuing, to prevent sand and salt water damage.)

3. The horizontal distance between stations may be predetermined using convenient standard intervals (i.e. 10 ft.) or it may be randomized, to the

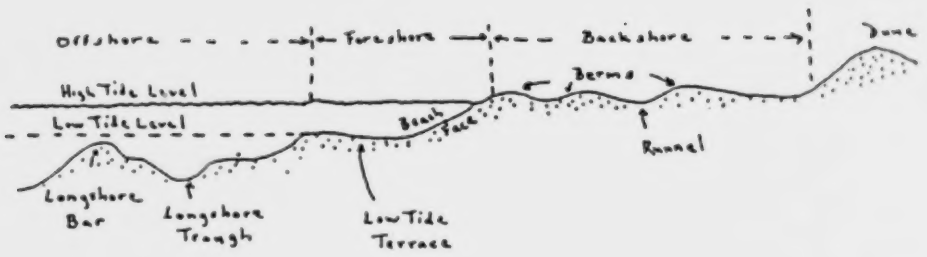

Figure 13 Coastal geomorphic features.

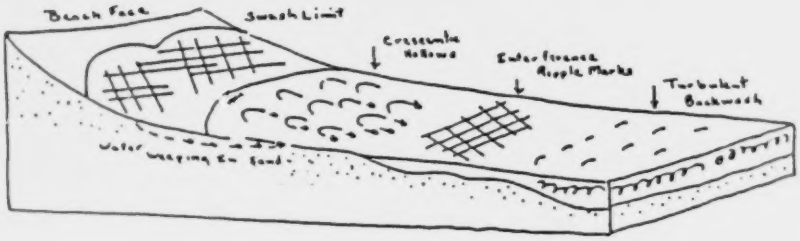

Figure 14 Beach face detail.

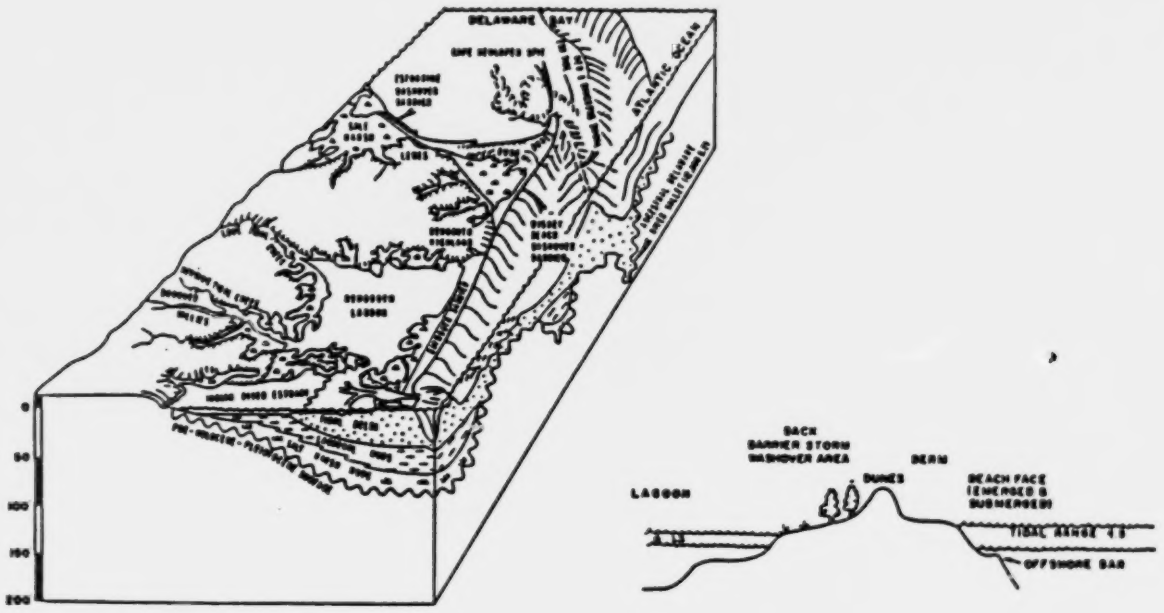

Figure 15 Delaware coastal geomorphic features and sedimentary environments.

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irregularities of the slope, however, both vertical heights (between the ground and the line of sight on the increment pole) and the horizontal distance between stations must be recorded accurately at each station.

4. From station 0, reverse the compass direction line of sight (landward, perpendicular to the shoreline) and with a level compass, have the rodman measure the vertical height between the line of sight and the ground surface at station 1 while the chainman determines the accurate horizontal distance (if you are using variable distances between stations). If there are small irregularities in the backshore zone like a ridge or runnel, these may be included in the profile without moving the tripod by recording precise vertical and horizontal measurements, (i.e., repeating step #3).

5. When the slope of the backshore exceeds the line of sight, you will need to move the compass and tripod/staff landward to a new station and repeat the leveling process, HOWEVER, you must record the horizontal distance between compass sighting stations and the vertical heights between the line of sight and the ground surface (see Figure 16).

NOTE: Backsighting to the previous compass location is a good check on accuracy. Repeat steps 3 - 5 as necessary across the dune, accurately recording data in the table. A new profile sheet should be made by the recorder for each profile with marginal notes reserved for various other observations and features.

B. Meter Stick Method. Starting either at the base of the dune or crest of the beach face, one person holds a meter stick (or increment material). A second person, using a second meter stick, carefully measures 3 meters horizontally and perpendicular to the shoreline from station 1 to station 2 and determines a line of sight back to station 1 by positioning his meter stick vertically. The difference in vertical height indicated by the line of sight is recorded on the data sheet (see Figure 17 & 19). The first student then walks to station 2 with his meter stick and places it vertically in position at station 2 while the second student measures the next 3 meter horizontal increment, keeping the profile line perpendicular to the starting point. The process is repeated over the profile, adapting the 3 meter horizontal increment to local surface variation where necessary, as long as the recorder accurately records the horizontal increment variation on the data sheet. Accuracy may be enhanced by use of a ball of twine and a line level for establishing the line of sight between the vertical meter sticks. As above (Brunton or Abney method), local details and features should also be noted. Note - It is wise for students to make a duplicate set of data to avoid accidental loss or damage before returning from the field.

C. Locke or Abney Level Method. The Locke level or Abney level may also be used as a simple sighting tube (with the clinometer of the Abney set at 0). Alternately, a simple sighting tube may be constructed according to the specifications in Figure 18.

Using either an observer of known height (ground to line of sight) or a meter stick or similar pole of convenient known length, a position is taken at the lowest point of the slope to be surveyed (A). Facing landward, the observer determines the point of the slope (B), intersecting with his

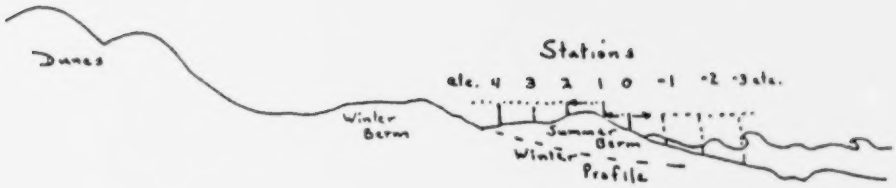


Figure 16 Brunton compass or Abney level method.

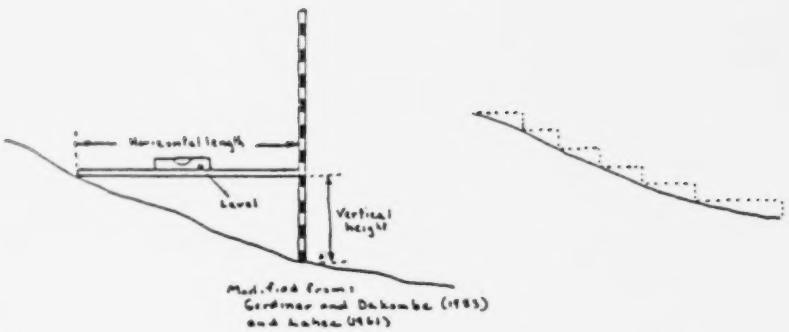


Figure 17 Meter stick method.

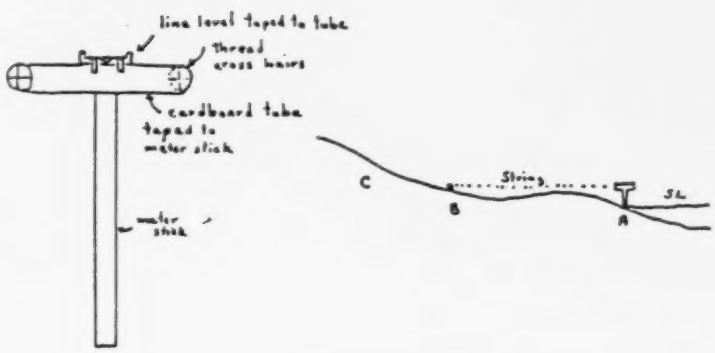


Figure 18 Locke or Abney level method.

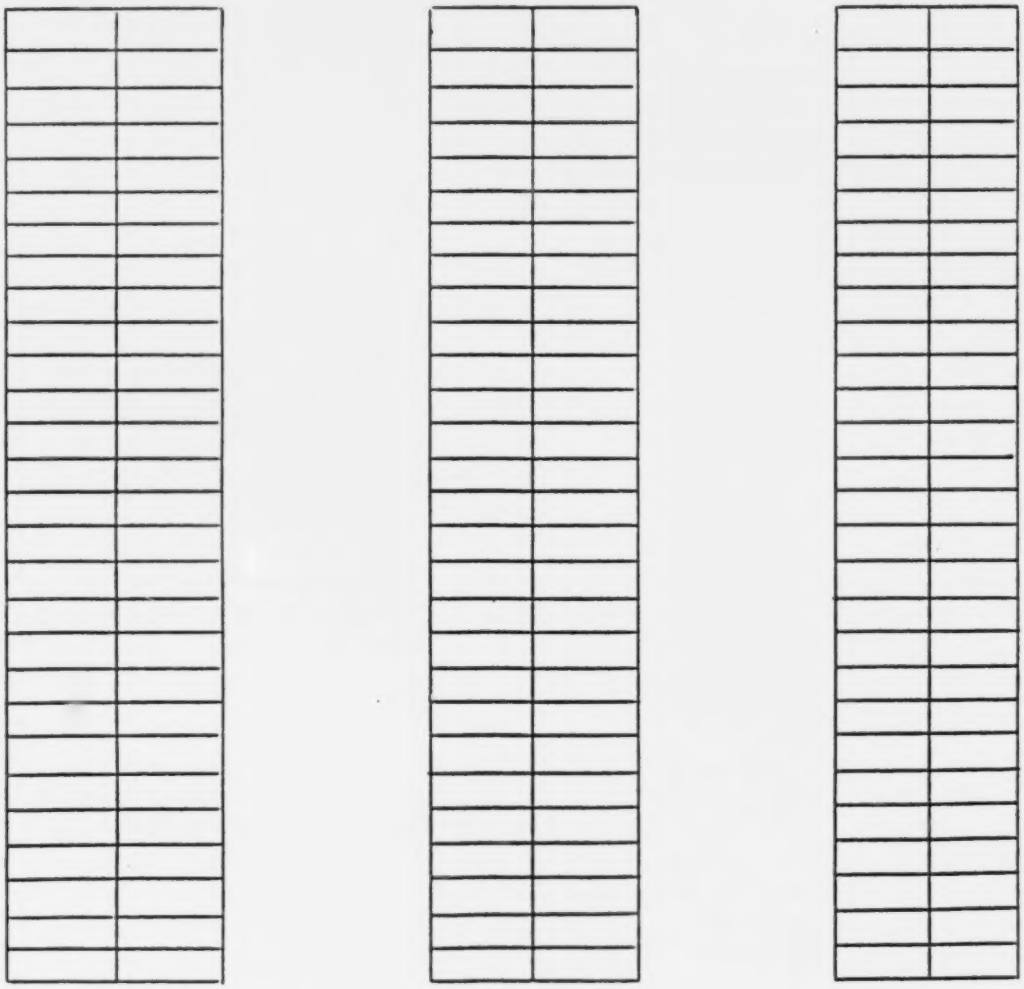
horizontal line of sight. A string marked in meters is stretched between A and B providing the horizontal distance between A and B. By measuring the height from the sand to the string at the intervals marked on the string, an excellent profile of the slope may be obtained. If the vertical elevation difference requires, the observer moves to station B, sights to station C and the above measurements are repeated.

Figure 19 Beach Profile Data Chart

Profile Designation _____

Date _____ Time Begun _____ Time Finished _____ Name _____

High Tide _____ Low Tide _____ Tidal Range _____



PLOTTING PROFILES

Profiles are best plotted on standard 10 x 10 graph paper. It is a good practice to plot the profile at different scales, often letting students choose increments they deem appropriate. This not only emphasizes subtleties in profile features, but invariably leads to discussion of appropriate degrees of exaggeration (the human eye only exaggerates 5x).

If a series of profiles are taken at the same location, or a series of locations through time, plots in different colors enhance comparison and observation of slope accretion and degradation. See Figure 20.

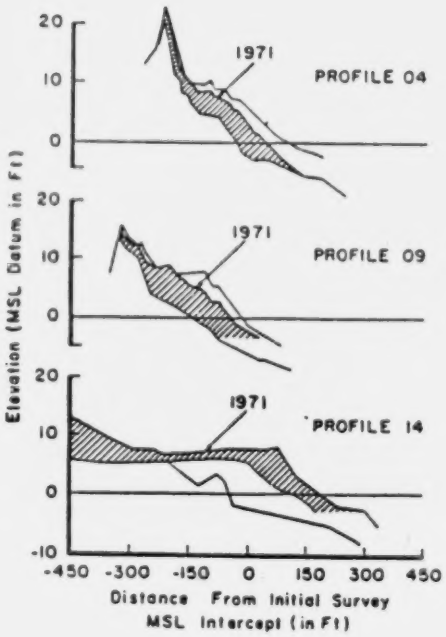


Figure 20 Profile bounds for 1969-1971 for beach profiles on Western Long Island. (Fisher Everts)

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LAMINATION, SEDIMENTATION AND WATER TABLE STUDIES OF THE BEACH

Trenching is one of the most instructive geological field techniques in the investigation of beach processes. With moderate effort, an understanding of the fundamental processes causing the form of the beach profile may be revealed. Samples may be obtained detailing both vertical and horizontal sediment variations, and photographs may be collected for subsequent comparison with later laboratory analyses. In addition, depth of the water table may be determined and related to water table determinations in the backshore zone by other methods.

Purpose:

1. To observe, measure and sample sediment beds and laminations to delineate and interpret recent erosional and depositional history of the beach exposed by trenching.

2. To determine depth of the water table in pits dug at intervals along the trench (subsequent to the above sediment study).

Materials:

Shovels, bricklayer's trowel or cement plastering trowel or knife, collecting materials: plastic bags and ties, label strips cut from 3 x 5 cards, felt tip pen, or 35 mm film canisters, tuna cans and masking tape, hand lens, notebook

Procedure:

1. Trenching. Dig a series of trenches, perpendicular to the shoreline, beginning at the lower foreshore and toward the dunes (upper foreshore). Two or three trenches (depending upon the width of the beach area), may be necessary. Each trench should be dug about 2-3 meters long, 3/4 to 1 meter wide and 1 meter deep, with one sidewall cut vertically so that the sun shines on it if possible (for photographic enhancement). Trim or clean the vertically cut sidewall and the landward endwall carefully with the trowel, knife, etc., so the sediment laminations can be seen (see Figure 21).

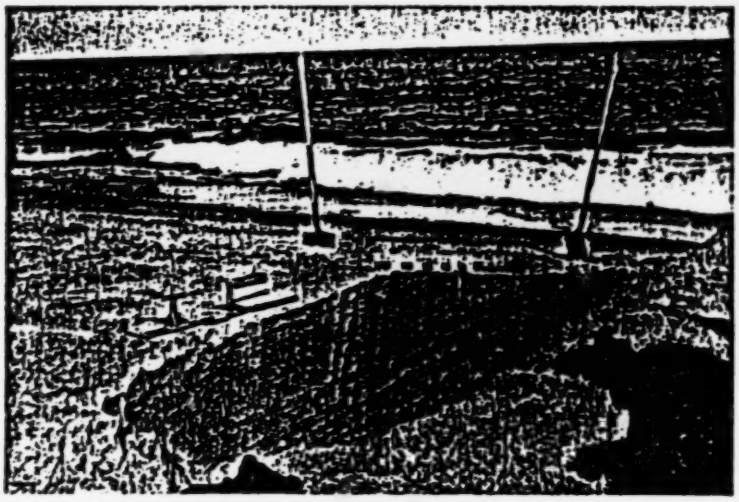

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Figure 21 The parallel lamination of the sand in the relatively flat beach-berm mass is truncated at the beach face, which indicates that active erosion is occurring at the time of the photograph. (After Kraft)

First, carefully observe the trend of the layers. Where present, the concentrations of heavy minerals in the sands assist in delineating the various events recorded in the layers of sediment. Note whether the layers are parallel to the surface of the besch, are transected by the surface (or other layers), or reveal a wavy pattern. Next, observe the relative thickness of the layers or any obvious particle size changes. Changes in stratification generally are the result of changes in wave amplitude or direction.

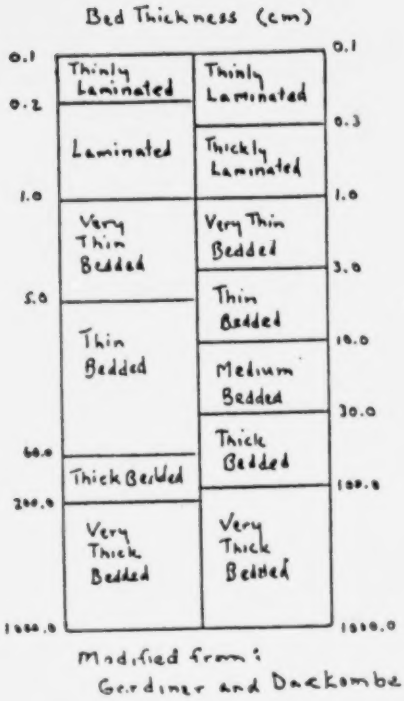
2. Trench Sketch. Make a detailed field sketch of the appearance of the layers in the sidewall and endwall of the trench in your notebook, label your sketch, noting bedding thickness, type and structure, as well as obvious particle size changes or heavy mineral concentrations and sorting variation (see Figure 22). Upon completion of the labeled field sketch, you may wish to photograph the strata as part of the record for later comparison with laboratory sediment analyses: a detailed field sketch and photograph are powerful interpretive tools.

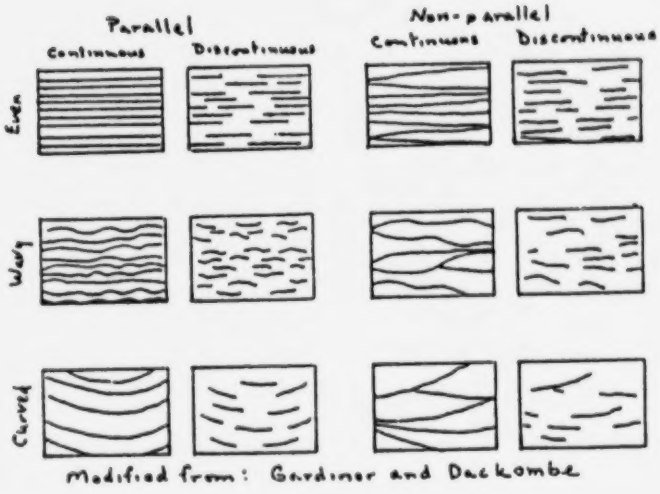
3. Sand Sampling. Sampling sediments to a large degree is dependent upon the purpose of the study, the requisite level of detail necessary to characterize variation observed and practical time constraints of the field season. Naturally, it is always better to collect more samples in greater amounts than you may later need for subsequent analysis, particularly when assessibility to the field site is in doubt.

Because sediment studies involve such a large total population and a large number of different sedimentary environments - the sampling plan must be executed carefully, so as to represent the total populations of the different environments in a manner that is both statistically correct and as representative as possible. Samples must be collected randomly within each environment and provisions must be made for assessment of the variability present both horizontally and vertically, in each environment. Obviously, the problem of describing sediments sccurately becomes complex quickly. (In some cases, it is desirable to take a small number of preliminary samples to ascertain the degree of variability. Where variability is great, more samples may be required.)

4. Sampling Plans. Generally, two basic types of sampling plans are utilized in depositional environment studies, with sample sites chosen randomly on either an area-interval or transect-interval basis. Area-interval are usually determined through utilization of grid intersection points, selected from a grid placed over the area to be sampled. Transect-intervals are determined by establishing a unit interval at which samples are collected along a transect line.

Two different types of samples may be collected at the sample sites, channel samples and stratified random samples. Channel samples consist of a vertical slice of the entire sequence of layers exposed in the trench or pit. Although this may appear to mask considerable detail at the exposure, channel samples may provide a quick collection procedure where contrasts in regional depositional environments are the primary emphasis. In situations where greater stratigraphic (or pedogenic) detail is advisable, a stratified random sampling procedure may be desirous. Stratified random sampling is merely an adaptation of the transect-interval to the vertical exposure of





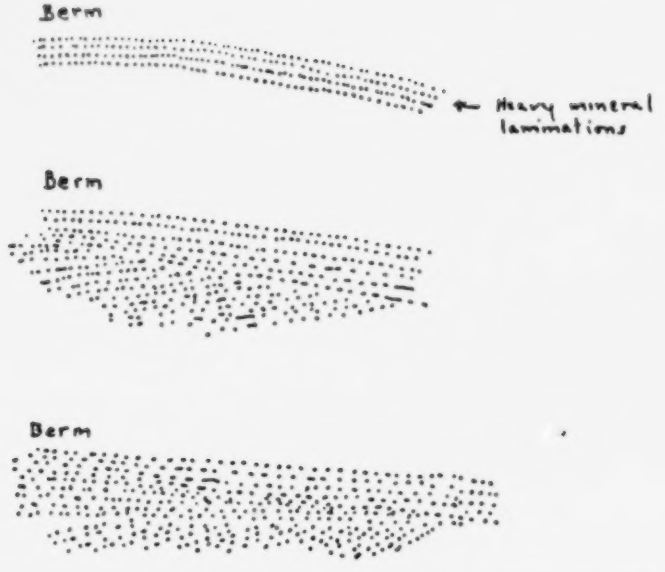


Figure 22 Bed and lamination characteristics.

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the pit or trench, in which samples are collected at specified intervals. Although more time consuming, this method has the added value of providing insight not only into regional contrasts of depositional environments, but also insight into stratigraphic temporal variations as well.

5. Sampling Procedure. Transect-interval, stratified random sampling. (Since many participants may desire to collect samples, we will only utilize this method.)

First determine the sampling interval along the trench. Mark this profile interval with a measuring tape along the exposed vertical wall of the trench. Next, using the tape (or meter stick), determine the vertical interval at which samples are to be collected from the profiles (a generally acceptable series of samples might be 6 profiles per trench x 5 samples per profile, yielding a total of 30 samples per trench).

Collecting samples from the bottom of the trench upward, using one of the sampling devices (35 mm film canister, tuna can trowel and plastic bag, tape peel, etc.) consistently at each predetermined interval. Label each sample carefully, identifying both its position along the trench and in the vertical exposure. Some field workers use a numbering system for the sample containers or tags, and then record this number in the field book along with other information about each sample, its site and other characteristics. Double wrapping samples and double labeling is a good precaution against potential data gaps. You may also identify sample locations in the field sketch.

If this sediment sampling procedure is repeated at each trench along the transect perpendicular to the shoreline, subsequent laboratory particle size analysis may reveal a strong association with measured changes in the beach profile. Effort should be made to collect sediment samples in each of the coastal environments: dunes, backshore, mid-foreshore and in the longshore trough.

6. Determination of the water table. Water table determination can be made utilizing at least part of the trench used for sand sampling, after samples have been collected. The hole may then be dug deeper, until the water flows into the hole. The depth from the beach surface to the water level in the hole should be recorded in the field book (or on graph paper), and subsequent holes dug and depths recorded, landward from the shoreline to the base of the dunes. This data may be incorporated with beach profile data to reveal the water table profile in the foreshore area. Comparison of data accumulated from pits during high and low tide periods, will allow determination of tidal effects on water table levels from cumulative or overlay graphic plots. See Figure 23.

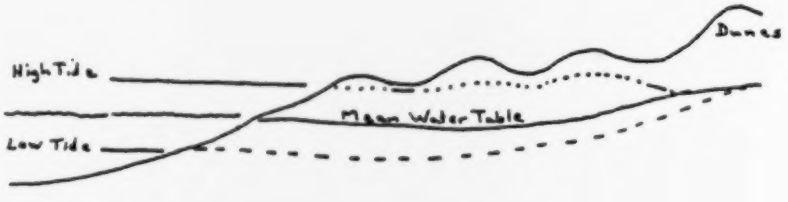

Figure 23 Tidal effects on the water table.

CORE SAMPLING SOFT SEDIMENTS

Sampling soft sediments can be so instructive, it's just plain fun! Once the core is successfully extracted, students can directly observe the changing depositional environment represented by the sample stratigraphic column. Additionally, the core provides material for particle size analyses, determination of regional facies relationships and biological studies including pollen analysis in the non-oxidized clays.

Purpose:

To demonstrate an economical technique for core extraction of soft sediments to depths of 15-20 ft. in soft sediments and provide an opportunity for further laboratory study of core samples.

Materials:

2" X 4" X 2', sledge hammer, jack modified for core extraction, pair grip pliers, gas main sealer, water, lengths of ABS plastic pipe 5' and 10', hack saw, masking tape, plastic sample bags. 2 investigators.

Procedure:

Select a site for sampling where there will be no apparent interference by roots of shrubs or trees. Clear a 6" diameter area of the ground surface of leaf letter. Hold the first 5 foot length of pipe in an upright position with 2 X 4 on top to absorb blows from the sledge hammer. Sledge the first five foot core down vertically to approximately 10 inches above the ground. Pour water into the air column above the soil; fill the column to the brim. Insert the gas main sealer and expand the rubber gasket by turning the flange. When the column is properly sealed, place the modified jack in the base, straddling the upright core tube and clamp the grip pliers on the core tube above the horizontal bars. Jack up slowly, listening for any vapor loss signifying a loss of core out the bottom of the sampler. As the bottom of the core approaches, use great care so the sample will not be shaken loose. Extract the tube, remove the sealer and water carefully, and cover immediately with plastic bags and tape. Insert the 10 ft. section to bottom of the hole carefully. Avoid dislodging sediment from the wall of the hole as much as possible. Repeat the above procedure (using the sledge hammer, etc.) and transport samples to lab for removal.

Note: A band saw does an excellent job splitting the core if fitted with a blade that will cut plastic pipe or, the core can alternatiyely be extruded into a piece of rain gutter and sliced with fine wire for further observation or even study of fossil pollen extracted from the non-oxidized clays. The address for the gas main sealer is Safety Gas Main Stopper Company Inc., 523 Atlantic Avenue, Brooklyn, N.Y. 11217. The price was approximately $5.00; provide them with the interior diameter of the pipe to the nearest 1/2 inch.

Figure 25 The gas-main safety seal which is inserted in the top of the pipe to prevent the core from slipping when the plastic pipe is retrieved.

LABORATORY ANALYSIS OF SEDIMENT SAMPLES: PARTICLE SIZE AND COMPOSITION

Although many characteristics of sediments can and should be noted in the field, detailed study is most easily accomplished upon return to the laboratory. Frequently, even samples obtained over distances as small as 1/4 mile, reveal distinct differences.

Basic to any detailed analysis of sediment is the determination of its size distribution. The most common method is to first dry the sediment, then sort 100-200 grams of it by placing it in a series of nested sieves. The series of nested sieves should reflect the range of size divisions according to one of the commonly accepted classifications (USDA, ASSHO, Wentworth or ϕ unit), and should be spaced at 1/2 ϕ or 1/4 ϕ units. See Figure 25.

If you do not have a set of sorting screens, a quite satisfactory set can be constructed using the following materials: metal mason jar bands, galvanized hardware cloth or screen (in sizes 2 X 2 squares per inch to 16 X 16 squares per inch), brass strainer mesh in 40, 50, 60, 80 or 100 squares per inch, and a tin can large enough to accommodate at least 5 of the stacked mason jar bands. Circles of each size wire may be cut and soldered into the mason jar bands. With screen arranged in the can, from finest at the bottom to coarsest at the top, sediments may be added slowly and shaken to allow for sorting. Sediments retained on each screen should then be dumped on paper and individual weights recorded for each of the screens per sample per site. Since sieving divides the sediment into volume frequency classes, an advantage of utilization of ϕ unit intervals is that sediment distributions may be plotted on graph probability paper on which a normal curve is plotted as a straight line. Normality of the distribution can be assessed, as well as other statistical measures (Folk, 1974). Tails of distributions revealed by this graphic plot often are particularly important in revealing the depositional environment of the sediment. See Figure 26.

Sieved samples may also be examined microscopically for mineral identification, magnetic properties, shape analysis or other characteristics. Such information frequently provides insight into beach material origins.

Figure 25 Wentworth and ϕ Unit Scales.

Size of Sediment Analysis

Type	*ϕ units*	*mm (Wentworth scale*
Boulder	more than −8·0	more than 256
Cobble	−8·0 to −6·0	256 to 64
Pebble	−6·0 to −2·0	64 to 4
Granule	−2·0 to −1·0	4 to 2
Very coarse sand	−1·0 to 0	2 to 1
Coarse sand	0 to 1·0	1 to 0·5
Medium sand	1·0 to 2·0	0·5 to 0·25
Fine sand	2·0 to 3·0	0·25 to 0·125
Very fine sand	3·0 to 4·0	0·125 to 0·0625
Coarse silt	4·0 to 5·0	0·0625 to 0·0312
Medium silt	5·0 to 6·0	0·0312 to 0·0156
Fine silt	6·0 to 7·0	0·0156 to 0·0078
Very fine silt	7·0 to 8·0	0·0078 to ·0039
Coarse clay	8·0 to 9·0	0·0039 to 0·00195
Medium clay	9·0 to 10·0	0·00195 to 0·00098

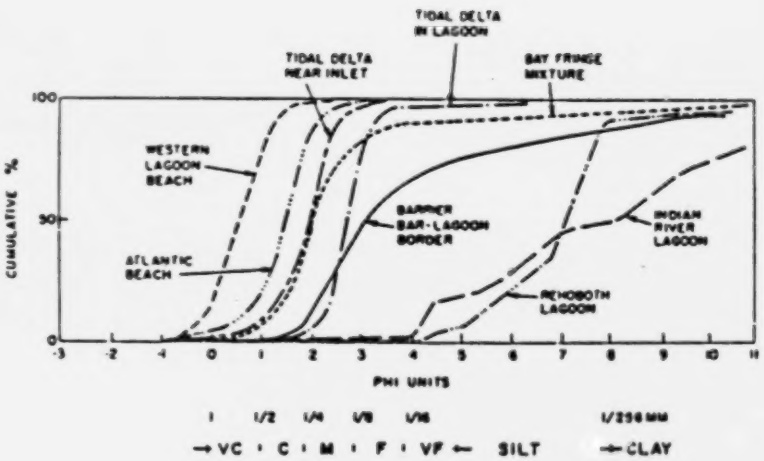
TIDAL DELTA IN LAGOON
TIDAL DELTA NEAR INLET
BAY FRINGE MIXTURE
WESTERN LAGOON BEACH
BARRIER BAR-LAGOON BORDER
INDIAN RIVER LAGOON
ATLANTIC BEACH
REHOBOTH LAGOON
CUMULATIVE %
100
50
0
-3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11
PHI UNITS
1 1/2 1/4 1/8 1/16 1/256 MM
→VC ↑ C ↑ M ↑ F ↑ VF ← SILT →CLAY
GRAIN SIZE ANALYSIS - COASTAL DELAWARE

Figure 26 Typical cumulative sediment-size curves for sedimentary environments in the Rehoboth-Indian River lagoon areas. (Kraft 1971)

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CHARACTERIZATION OF AN IMMATURE SOIL

In eastern Delaware, between Delaware Bay and the Atlantic Ocean, a soil association consisting of Tidal marsh - salty, and salty Coastal beach and dune land predominates. This association occupies approximately 5 percent of the entire county land area, of which the Tidal marsh unit comprises about 80 percent.

The Tidal marsh - salty (Tm) soil map unit, so common in nearshore areas, consists of an open grassy marsh marked by tidal streams and mosquito-control ditches. Although soil materials vary greatly in relation to salinity and elevation to mean high tide, a representative profile is provided on page . This profile was obtained from "a level, undisturbed area 350 feet east of Oyster Rocks Road and 475 feet south of the Broadkill River in Great Marsh, Delaware."

In comparison, the salty Coastal beach and dune land (Co) consists of loose sand that has been, and frequently still is, subject to wave, tide and wind action. Although these areas are intensively used for recreation, the dunes form a protective barrier against storm tide surges and waves for the marshes behind them. Ramps and controlled access points are frequently needed for foot and vehicular traffic, to minimize environmental stress. Major storms and hurricanes may result in significant damage to both dunes and buildings within this map unit. Septic system drainfields are likely to malfunction and contaminate both groundwater and nearby open water, due to the prevailing rapid permeability and severely fluctuating water table.

Purpose:

1. To observe a representative profile of the Tidal marsh - salty, soil unit and collect samples for subsequent laboratory particle size analysis;

2. To practice field description or measurement of the following soil characteristics: horizon boundaries, soil color, structure, stickiness. plasticity, pH.

Materials:

Oakfield tube auger, plastic sandwich bags and ties, 3 x 5 cards for sample identification, soil pH kit, Munsell color charts, USDA Soil Survey Manual

Procedure:

1. Using the Oakfield tube auger (with wet soil tip) insert the auger into the soil, filling the core tube. Twist clockwise and extract the tube from the soil. Alternatively, procedures for plastic tube coring may be followed (p. 28).

2. Record the characteristics observable in the soil tube on the table provided (depth, color, mottling, approximate horizon thickness, moisture, etc.). Carefully remove the sample from the tube, verifying previous observations, completing the remainder of the notations in the appropriate portion of the table and store the sample in double-wrapped plastic sandwich bags and ties. Label the sample, identifying the site nimber or location, the number of the sample and depth immediately.

3. Re-insert the auger into the hole carefully, avoiding contamination of the tube sample through rough contact with the walls of the hole. Fill the core tube and retract as above. Since some contamination of the sample may occur upon reentry, you may wish to record observations as above, but save only the lower 6 inches (?) of the sample for subsequent lab analysis (i.e. particle size, coarse fragment identification, pollen, etc.). Repeat this procedure for the two meter section where local site conditions permit, to observe the vertical changes in sediment parent material and soil forming processes. Note also, the differences from a hypothetical soil profile having all the principle horizons in Figure 27.

Figure 27 Typical Tidal marsh - salty (Tm) Soil Profile.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) clay loam; no apparent structure; sticky and plastic; matted, fibrous roots; roots and plant remains estimated at more than 50 percent of wet volume; organic-matter content 13 percent by weight; N-factor less than 0.5; shrinkage about 36 percent from wet to dry condition; mildly alkaline when wet, slightly acid when dry; clear, smooth boundary.

C1g—5 to 18 inches, bluish-gray (5B 5/1) silty clay loam; massive; plastic and very sticky; many fibrous roots; roots and plant remains estimated at about 20 percent of wet volume; organic-matter content 3.2 percent by weight; N-factor greater than 0.5; shrinkage about 28 percent from wet to dry condition; neutral to mildly alkaline when wet, extremely acid when dry; sulfurous odor; abrupt, smooth boundary.

C2g—18 to 93 inches, dark-gray (10YR 4/1) loam; massive; sticky and slightly plastic; many roots in upper part; roots and plant remains estimated at nearly 50 percent of wet volume; organic-matter content 10.5 percent by weight; N-factor greater than 0.5; shrinkage about 40 percent from wet to dry condition; neutral to mildly alkaline when wet, strongly acid to very strongly acid when dry.

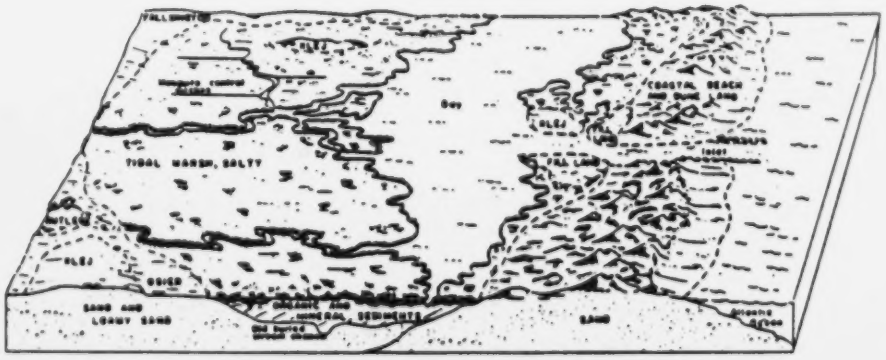

Figure 28 Typical pattern of soils and underlying material in association 1.

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Figure 29 Soils Data Sheet

Traverse No. _____ Soil Profile No. _____

Air Photo No. _____ Photograph No. _____

Horizon	Depth	Mottling Size color	Moisture D M W	Consistence Stickiness NS SS S VS	Consistence Plasticity NP SP P VP	Greater than 2 mm Size D_s D_l D_i	Greater than 2 mm Shape Roundness	Texture Pebble Lithology

Stoniness

Parent Material

Topography -- % Slope
8, 8-16, >16

Geologic Formation

Drainage/Seepage Zones

Vegetation

Unique Air Photo Characteristics

(DATA SHEET page 1 cont.)

Temperature _____

Elevation _____

Less than 2 mm Feel Smooth Gritty	Structure Type Size Grade	Clay Films Occurrence Grain Stains	Clay Films Occurrence Bridges	Clay Films Occurrence Align pores/peds	Clay Films % Freq.	Clay Films Thickness Thin M Tk	Reaction pH/eH

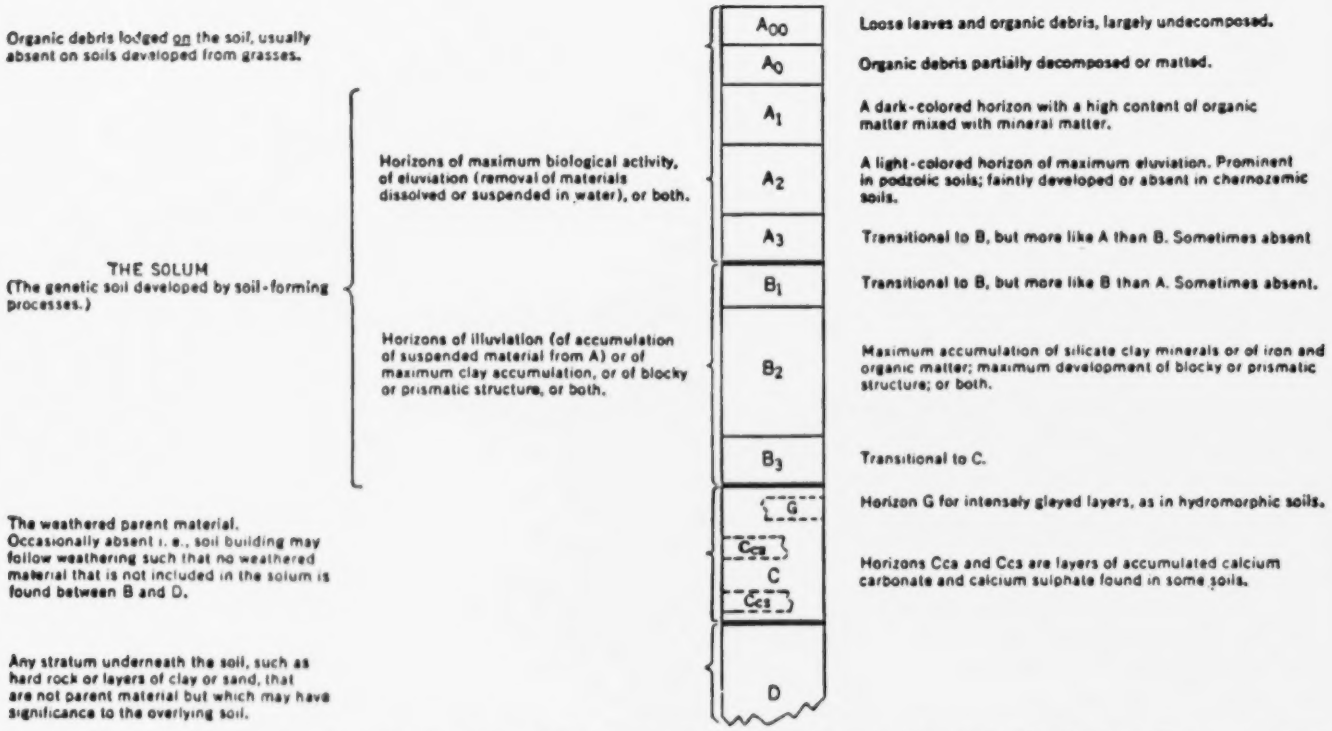
Organic debris lodged on the soil, usually absent on soils developed from grasses.
THE SOLUM
(The genetic soil developed by soil-forming processes.)
Horizons of maximum biological activity, of eluviation (removal of materials dissolved or suspended in water), or both.
Horizons of illuviation (of accumulation of suspended material from A) or of maximum clay accumulation, or of blocky or prismatic structure, or both.
The weathered parent material. Occasionally absent i. e., soil building may follow weathering such that no weathered material that is not included in the solum is found between B and D.
Any stratum underneath the soil, such as hard rock or layers of clay or sand, that are not parent material but which may have significance to the overlying soil.
A00
A0
A1
A2
A3
B1
B2
B3
G
Cca
C
Ccs
D
Loose leaves and organic debris, largely undecomposed.
Organic debris partially decomposed or matted.
A dark-colored horizon with a high content of organic matter mixed with mineral matter.
A light-colored horizon of maximum eluviation. Prominent in podzolic soils; faintly developed or absent in chernozemic soils.
Transitional to B, but more like A than B. Sometimes absent
Transitional to B, but more like B than A. Sometimes absent.
Maximum accumulation of silicate clay minerals or of iron and organic matter; maximum development of blocky or prismatic structure; or both.
Transitional to C.
Horizon G for intensely gleyed layers, as in hydromorphic soils.
Horizons Cca and Ccs are layers of accumulated calcium carbonate and calcium sulphate found in some soils.

FIGURE 30 A hypothetical soil profile having all the principal horizons. It will be noted that horizon B may or may not have an accumulation of clay. Horizons designated as C_{ca} usually appear between B_3 and C. The G may appear directly beneath the A.

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PLANT COMMUNITIES IN NEAR-SHORE AREAS

In order to present a definitive picture of the kinds of plants present in near-shore communities and their relationships in this type of environment, we will take two types of samples: the nested quadrat and the line-intercept transect.

Purpose:

1. To learn the composition and structure of the plant community as a basis for ecological study;

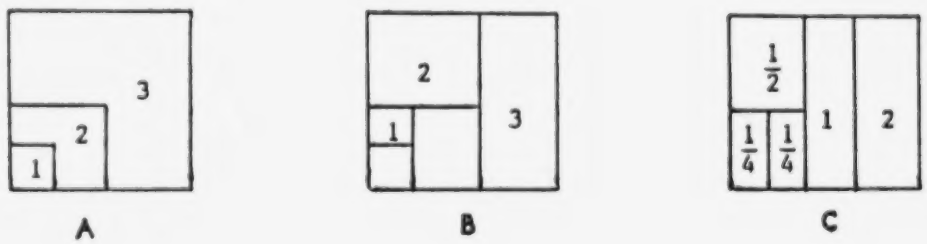
2. To observe how abiotic and biotic factors of a coastal dune area interact to form a distribution of plant communities by line-intercept or belt-transect methods.

Materials:

Two lengths of rope and 2 meter sticks, 150 foot measuring tape (or rope pre-marked at 1 foot intervals), light meter, wet bulb-dry bulb thermometer, soil thermometer, wind meter, (for each student team)

Procedure:

A. The Quadrat Sample. The quadrat mathod of sampling natural vegetation is by no means limited to ecology, but has almost unlimited applications. The type we use here is the nested quadrat. Using two meter sticks, lay out a square one meter on a side, then subdivide it with the rope according to one of the following methods:



List the type of plants and their frequency, in each of the different sized quadrangles. Later in the lab, construct a histogram of frequency of the observed species.

B. The Transect Sample. A transect is a sample strip extending across a stand or several stands of vegetation. It is most often used when differences in vegetation are apparent and are to be correlated with other factors. From a river floodplain, to an adjacent upland, there would be marked changes in moisture conditions, therefore we might expect different plant to reflect these varied moisture conditions. Similarly, plant successions commonly are present on dune lee sides. A transect landward from the berm commonly exhibits the changes in abiotic factors (light intensity, soil conditions, relative humidity, wind velocity, and temperature) defining a succession of plant communities.

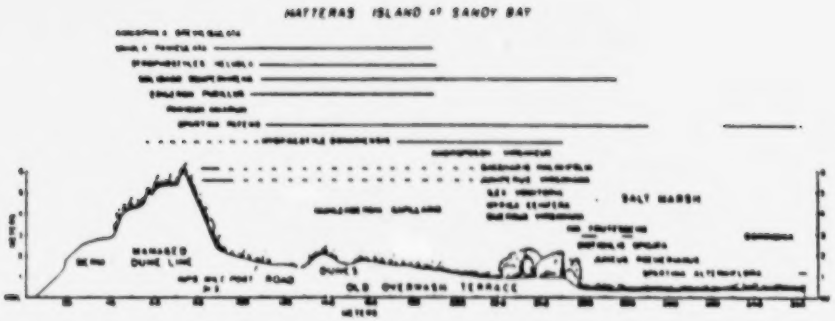


Figure 31 Elevation profile and vegetation sequence across Hatteras Island at Sandy Bay. Note the shape of the dune and the narrow beach compared to Core Banks. Dune vegetation is typical of the region except for the American beach grass *(Ammophila breviligulata)*. While the species distribution is similar to that of Core Banks, zones are much closer to the sea and much denser on the dune, a result of fertilization. While not listed here, typical salt marsh species such as those on Core Banks are present at Sandy Bay. Of particular note is the shrub zone developing along the backside and advancing seaward. (After Godfrey)

Pre-trip preparation.

1. Select a location for the area to be sampled from available topographic maps and aerial photographs to maximize both access efficiency in the field and accuracy in characterization of the plant successions to be sampled;

2. Rehearse the study techniques to minimize adverse environmental impact resulting from thoughtless sampling behavior. RESPECT THE FRAGILE NATURE OF THE DUNES. A list of rules for all to follow may be desirable.

In the field.

1. Lay out the rope or measuring tape over the first transect section perpendicular to the shoreline. Simultaneous parallel transects may be undertaken by several student teams if equipment and time permits.

2. Follow these lines, recording the abiotic and biotic conditions at regular intervals (1 or 2 meters or your choice) through the following suggested sites: beachface, berm surface, windward dune face, dune crest, leeward dune slope, swale between the dunes, salt marsh. As an additional activity, you may leave a maximum/minimum thermometer at each of the above sites (except the beach face), for the duration of the other recording activities. The table on the following page is provided for your observations record.

3. Record the presence, approximate height and area of each plant species at the chosen intervals. Note: if the measuring tape or incremented rope is not held horizontally, but laid on the ground surface, the steepness of the slope will alter sample plot size (i.e. plots will be non-uniformly sized).

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4. If teams constructing a transverse profile (beach to salt marsh), and the vegetative transect study share data, a composite profile may be drawn on graph paper with the appropriate vegetative symbols and key added. Graphs of the abiotic variables may be compared, using either acetate overlay methods, or a multi-color line plot technique.

5. In subsequent years, construct new profiles and record new vegetation on new and old graphs. Comparisons may reveal successions and the relative success of vegetation and the abiotic factors in the study area, particularly if dune activity is a factor. Suggestions for management alternatives may be considered.

Figure 32 Abiotic Factors In Coastal Environments Data Sheet.

Sites	Light Intensity	Soil Texture + Horizons	Soil Temperature	Air Temperature	Max/Min. Temperature	Relative Humidity	Wind Velocity	Vegetation Species - Frequency
Beach Face								
Berm								
Windward slope, Dune 1								
Top Dune 1								
Leeward slope, Dune 1								
Swale between Dunes 1 + 2								
Top Dune 2								
Salt Marsh								

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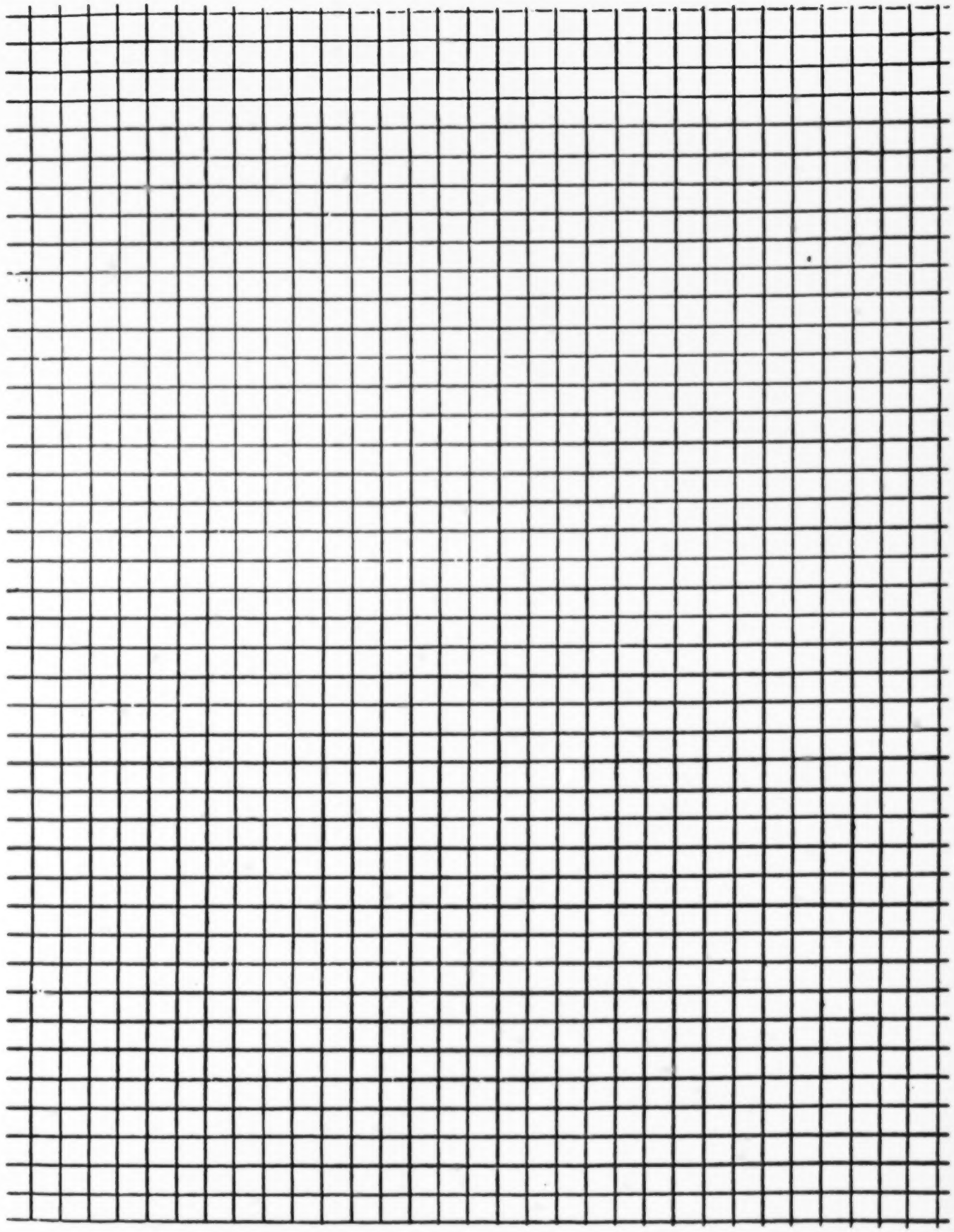
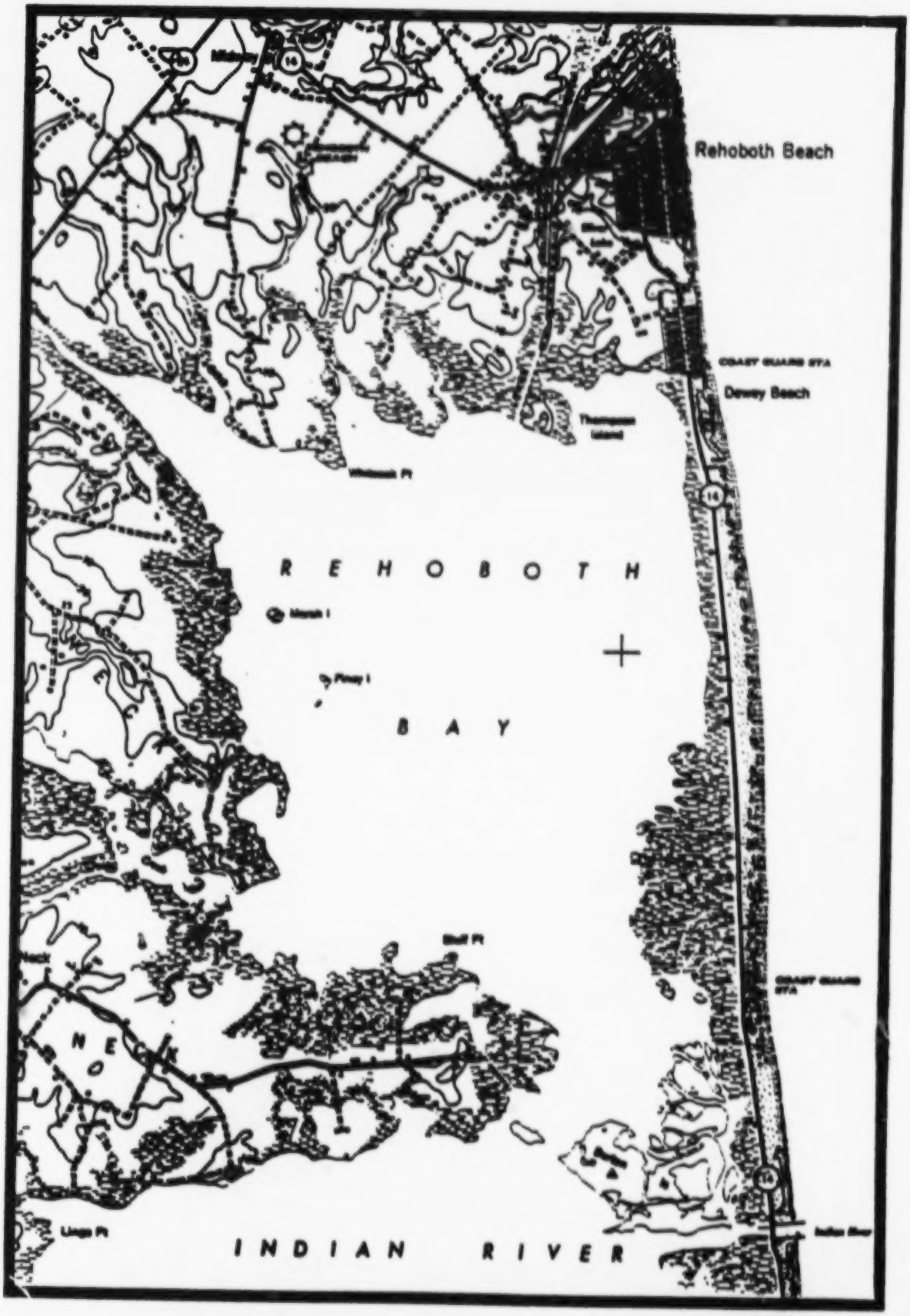


NOTES

REHOBOTH, DELAWARE

SCALE 1:62500 CONTOUR INTERVAL 10 FEET



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